MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

FISHERIES DIVISION
JOB PROGRESS REPORT

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TITLE: STATEWIDE FISHERIES INVESTIGATIONS
TITLE: SURVEY AND INVENTORY OF COLDWATER LAKES
TITLE: HAUSER AND HOLTER RESERVOIRS STUDY
PART A: YEARLY MONITORING EFFORTS
PART B: FLUSING LOSSES OF HATCHERY RAINBOW TROUT FROM THREE MID-MISSOURI RIVER RESERVOIRS.

PROJECT PERIOD: JULY 1, 1995 THROUGH JULY 1, 1996

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PART A

YEARLY MONITORING EFFORTS

ABSTRACT

Fisheries data were gathered on Hauser and Holter reservoirs to provide information needed to: 1) manage the fishery of the two reservoirs; 2) evaluate impacts of existing reservoir operations on the sport fishery; and 3) evaluate the success of the hatchery stocking program. The composition of fish species in the horizontal gill nets in Hauser Reservoir in 1995 was similar to catches in previous years. Kokanee dominated the catch in floating gill nets, while white suckers dominated the sinking gill net catch. Walleye continued to make up less than 1% of the catch in sinking gill nets, in spite of yearly plants of 3,000-5,000 fingerlings since 1989. The number of kokanee in vertical gill nets averaged 47.5/net night in 1995. Only the age 1+ year class of kokanee was considered to be strong. A hydroacoustic survey was conducted in April 1996 in order to estimate the kokanee population in both Hauser and Holter reservoirs; however,

the data analysis has not been completed at this time. A total of 1,024 anglers were interviewed during the summer of 1995 on Hauser Reservoir. Yellow perch followed by kokanee were dominant in the catch, together comprising 83% of the total. Angler catch rate of rainbow trout and kokanee was 0.05 and 0.11/hr, respectively. Mean length of the same two species was 17.5 and 17.0 inches, respectively. Kokanee were the overwhelming favorite as the most popular target species selected by anglers. In response to questions about their fishing experience, 24.9% of the anglers said they were satisfied with the number of fish caught, while 70.5% of those who caught fish were satisfied with the size of the fish. Yellow perch dominated the catch in the 1994/95 winter fishery on Hauser Reservoir, composing 81.7% of the catch; kokanee were the second most frequently taken fish, comprising 10.7% of the catch.

In Holter Reservoir in 1995, rainbow trout and kokanee dominated the catch in the spring floating gill nets, while rainbow trout and white suckers dominated the catch in the fall floating gill nets. Yellow perch, white suckers and longnose suckers dominated the catch in both spring and fall sinking gill nets. Catch rates for walleye were at a record low in both the spring sinking gill nets (1.00 fish/net) and the fall sinking gill nets (0.50/net). The average length of walleye in the spring and fall nets was 22.5 and 16.4 inches, respectively. The catch rates for kokanee in the vertical gill nets were at record high levels in 1995, with 85.5 fish/net for all age classes. Most of these fish were age 1+, which were caught at a rate of 77.0/net. Trap nets were fished in April and May and captured 243 spawning walleye. A total of 192 walleye were tagged with both red dangler tags and jaw tags; the remaining 51 fish had been previously tagged (19 in 1996, 32 in previous years). A total of 800 anglers were interviewed during the summer on Holter Reservoir in 1995. Rainbow trout dominated the catch made by anglers (59.1%), followed by yellow perch and kokanee. Catch rate for rainbow trout was 0.30/hr. About 53% of the rainbow trout harvested were of known hatchery origin, while 59% of rainbow trout captured in gill nets were of hatchery origin. The target species selected by anglers was evenly split over four categories (Any Trout, Any Fish, Kokanee and Trout, Kokanee). Answers to angler-satisfaction questions revealed that 19.9% of the anglers were satisfied with the number of fish caught, while 49.3% of the anglers who caught fish were satisfied with the size

of the fish. Yellow perch dominated the composition of the catch during the 1994/95 winter ice fishery on Holter Reservoir. Angler catch rates for yellow perch and rainbow trout were 0.45/hr and 0.04/hr, respectively.

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PROCEDURES

The study area has been previously described by Rada (1974), Berg and Lere (1983) and MDFWP (1985). A map of the two reservoirs is presented in Figure 1.

Reservoir fish were sampled with floating and sinking 6 x 125 foot experimental gill nets (0.75 to 2 inch mesh). Nets were set in each reservoir during the spring and fall in similar locations to those used between 1986-1994. Distribution of fish species by depth was determined by using a gang of six vertical gill nets that were 150 feet deep and 12 feet wide (0.5, 0.75, 1, 1.25, 1.5 and 2.0 inch mesh). Vertical nets were set monthly from April through October at permanent sampling stations located at the lower end of each reservoir (the Dam station on Hauser Reservoir and the Jackson station on Holter Reservoir) and mid-reservoir (below the powerlines) on Hauser Reservoir. Single-lead trap nets (4 x 6 foot frame and 1-inch mesh) were used to sample spawning walleye on Holter Reservoir in spring 1996.

A partial creel census was conducted on Hauser and Holter reservoirs from early April through late October. Procedures for this partial creel census are described in Lere (1987). An additional partial creel survey was conducted during ice cover on the two reservoirs from early January through early March.

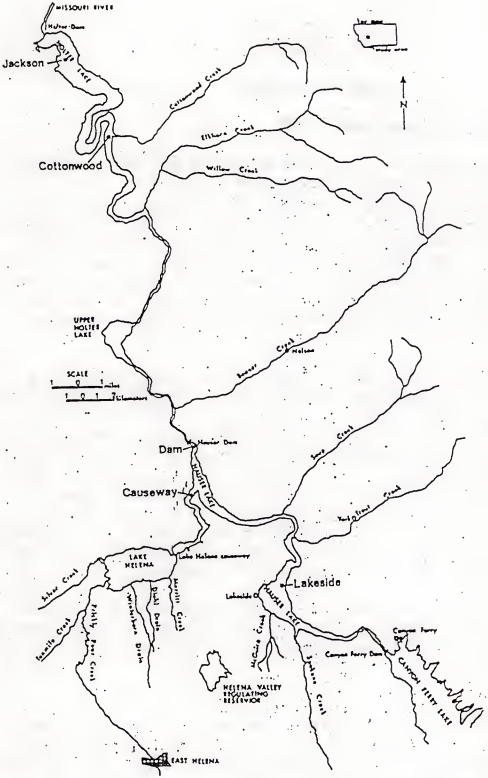

Figure 1. Map of Hauser and Holter reservoirs showing locations of permanent sampling stations. Lakeside, Causeway and Dam stations are on Hauser Reservoir. Cottonwood and Jackson stations are on Holter Reservoir.

RESULTS

Hauser Reservoir

Fish Abundance and Distribution

Floating gill nets. Relative abundance of fish captured in floating gill nets in 1995 is presented in Table 1. The composition of the catch was similar to past years, with kokanee dominating the catch in both spring and fall. Rainbow numbers were unusually high in the spring, but were typical of normal catch levels in the fall. Sucker catches in the spring and fall decreased markedly from 1994, when the combined catches of both species was 33.6% in the spring and 26.7% in the fall. Sucker catches in spring 1995 decreased to 1.6%, while fall catches decreased to 2.2%.

Since 1986, rainbow trout catch rates in the spring nets have been fairly stable--with the exception of the extremely high catch rate in 1986 (Figure 2, Appendix Table 1). The marked increase in the spring of 1995 was due to rainbows which had drifted out of Canyon Ferry Reservoir and comprised about 87% of the total rainbow catch. Catch rates in the fall have shown a slow downward trend (Figure 3). About 74% of rainbow trout collected in gill nets in 1995 were of known hatchery origin. It is important to note that the rainbow trout planted in 1994 were not marked. This would potentially increase the number of fish of known hatchery origin if they had been marked.

Kokanee catch rates were lower in spring 1995 than in any year since 1986 (Figure 4). Fall catch rates were higher than in 1994; however, they were still much lower than the fall catch rates from 1989-1992.

Sinking gill nets. Relative abundance of fish captured in sinking gill nets in 1995 are shown in Table 1. White suckers dominated the catch in both spring and fall. This has been true for every year since 1986 (Appendix Table 2). Yellow perch numbers continue to decline from the record catch in 1992 (21.5%). Their percentage of the total catch (3.1%) was at an all-time low in 1995. Walleye continue to make up less than 1%

of the catch in sinking nets, in spite of yearly plants of 3,000-5,000 fingerlings since 1989. In 1995 no walleye were captured in sinking nets.

Table 1. Percent composition by species and season for gill net catches in Hauser Reservoir in 1995.

	Sinkers		Floaters	
Species	Spring	Fall	Spring	Fall
RB	0	0.3	45.7(39.0)[a]	13.1
LL	1.4	0.5	1.6(1.0)	2.2
KOK	1.9	18.9	51.2(58.1)	81.4
MWF	2.7	0.3	0	0.5
WE	0	0	0	0
YP	3.1	8.0	0	0
LNSU	18.6	18.1	0.8(1.0)	0
WSU	70.7	50.5	0.8(1.0)	2.2
CP	1.0	0.2	0	0
UC	0.2	0.3	0	0.5
BURBOT	0.4	2.8	0	0
Total # Caught	484	576	129(105)	183
Number nets	6	7	11(9)	11

[a]Data includes two new net sites. Numbers in parentheses indicate traditional net sites only.

Vertical gill nets. The number of kokanee collected in vertical nets in 1995 was 47.5 per net night when the traditional mesh sizes were used. This is a slight increase over catch rates from 1994 (36.4/net night). The age 1+ fish were the strongest of the year classes, averaging 41.9 fish/net night, the highest for this age class since 1989. If the two additional nets (0.5 and 2.0-inch mesh) are included in the calculations, the average fish/net night was at an all-time high for the 0+, 1+, 3+ and total fish categories. The high catch rate of age 1+ fish

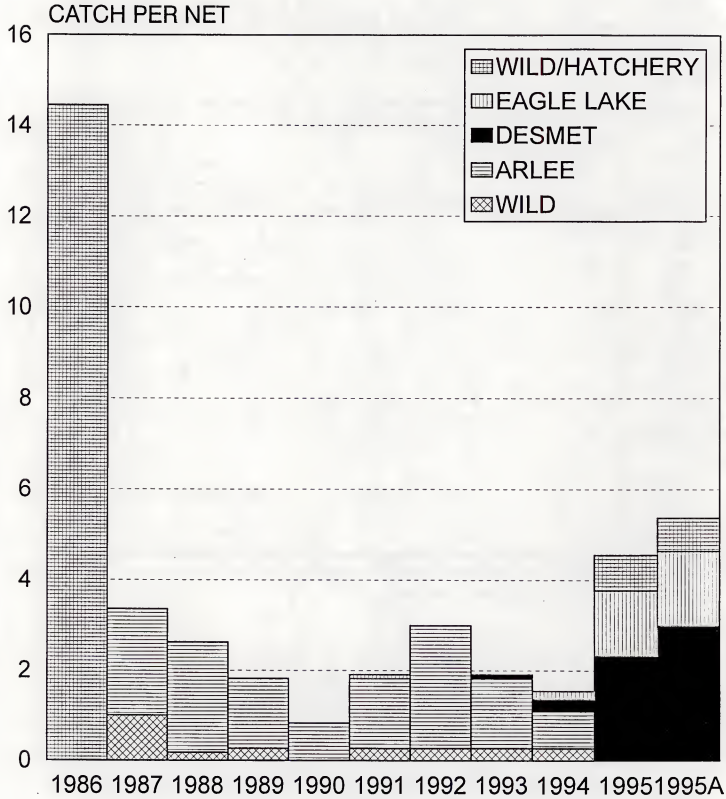

Figure 2. Catch rates for rainbow trout in floating gill nets in Hauser Reservoir, Spring 1986-95. 1995A includes data from two new net sites.

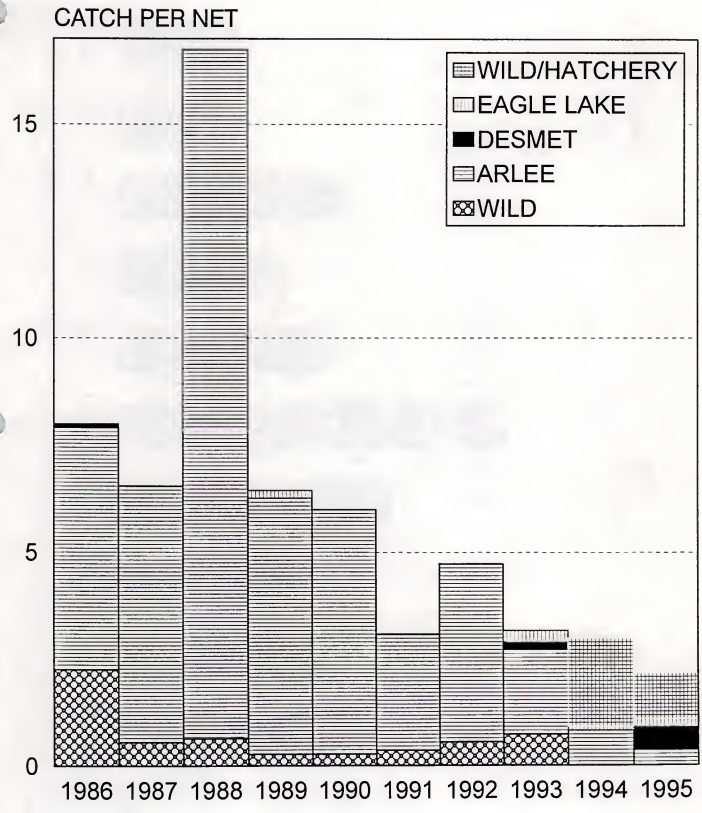

Figure 3. Catch rates for rainbow trout in floating gill nets in Hauser Reservoir, Fall 1986-95.

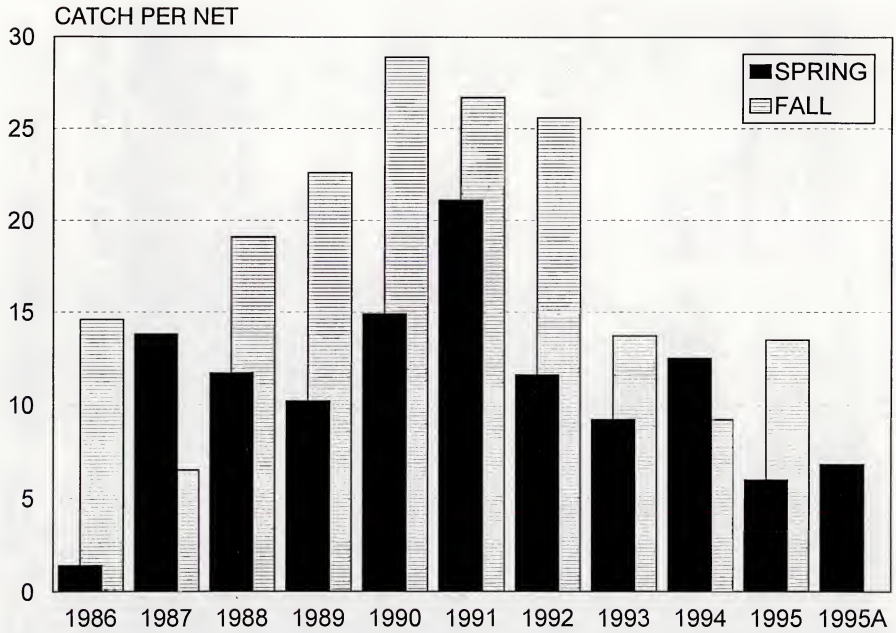

Figure 4. Catch rates for Kokanee in floating gill nets in Hauser Reservoir, 1986-95. 1995A includes data from two new net sites.

(130.9/net night) was largely the result of the April netting where 608 age 1+ kokanee were caught in one net night.

Table 2. Mean catch rates (fish per net night) by age class for kokanee collected in vertical nets set at the Dam Station in Hauser Reservoir from 1986 through 1995.

Year	No. sets	Number of kokanee per set				
		Age 0+	Age 1+	Age 2+	Age 3+	Total
1986	3	0	21.7	6.3	0	28.0
1987	4	0	32.3	7.5	0.2	40.0
1988	5	0.4	100.6	4.8	3.0	108.8
1989	6	0	36.7	44.0	0.6	81.3
1990	7	0.1	35.7	22.5	3.4	61.7
1991	5	0	4.2	24.4	0.4	29.0
1992	7	0	14.6	10.1	2.0	26.7
1993	6	0	5.7	4.3	0.3	10.3
1994	5	0	10.8	24.6	1.0	36.4
1995	7	0	41.9	3.7	1.9	47.5
1995[a]	7	1.7	130.9	4.1	3.6	140.3

[a]Data include two additional nets - 0.5 and 2.0 inch mesh for a total of six vertical nets/night. Length-frequency data were used to age all fish in 1995.

Beach Seining. Numbers of forage fish captured per tow in 1995 are shown in Table 3. Most of the fish were young-of-the year, but a few were age 1+ and older. Sucker and yellow perch numbers have declined dramatically since 1993.

Summer Creel Census

A total of 1,024 anglers were interviewed on Hauser Reservoir during the summer period (April through October) in 1995. As with 1994, the interviews were done almost exclusively during the weekends. Distribution of interviews, mean hours per fishing trip and mean number of anglers per fishing party are presented in Table 4.

Table 3. Number of fish per beach seine tow in Hauser Reservoir 1990-1995.

YEAR	NUMBER OF TOWS	Y. PERCH TOTAL	SUCKER TOTAL	WALLEYE TOTAL
1990	2	15.5	--	0
1991	20	36.6	--	0
1992	20	1153.1	107.6	0
1993	20	145.0	1105.9	0
1994	20	52.8	729.6	0
1995	20	47.0	187.5	0.1

Table 4. Distribution of interviews by day of week and by method of fishing with mean hours per completed fishing trip and mean party size obtained on Hauser Reservoir during the summers of 1986 through 1995.

	Percent of total interviews					
Year	Weekday	Weekend	Shore	Boat	Mean hours Fished/trip	Mean # of anglers/party
1986	38	62	58	42	3.96	2.98
1987	49	51	60	40	3.93	1.87
1988	48	52	48	52	4.18	1.93
1989	61	39	54	46	4.07	1.90
1990	48	52	55	55	4.03	1.85
1991	37	63	25	75	4.63	2.07
1992	53	47	39	61	4.67	2.37
1993	45	55	53	47	5.20	2.32
1994	2	98	39	61	4.40	2.79
1995	3	97	44	56	5.02	2.46
Average	38	62	47	53	4.41	2.25

Table 5 presents the composition of the catch made by anglers during the summer fishery in 1995. Kokanee and yellow perch dominated the catch in 1995. Yellow perch composed an all-time high percent of the catch in 1995 (49.3%), while the rainbow trout percentage increased to 14.6%.

Table 5. Composition of the catch by anglers on Hauser Reservoir during the summers of 1986 through 1995.

		Percent composition of catch						
Year	Number caught	Rainbow trout	Brown trout	Kokanee	Yellow perch	Mtn. white-fish	Small-mouth bass	Walleye
1986	2,728	49.9	1.4	26.7	21.6	0.3	0.2	0
1987	3,912	47.6	0.4	30.4	20.3	1.2	0.1	0
1988	3,882	45.3	0.3	43.6	10.6	0.2	0	0
1989	3,247	18.1	0.3	65.8	15.5	0.4	0	0
1990	3,870	21.2	0.5	44.2	33.8	0.2	0	0
1991	6,935	4.3	0.2	81.5	13.7	0.3	<0.1	0
1992	3,565	11.9	0.4	49.6	37.9	0.2	0	0.1
1993	2,532	16.8	0.6	68.4	14.1	0.1	0	0
1994	1,616	5.4	1.2	46.3	46.7	0.1	0.3	0
1995	1,287	14.6	0.8	34.1	49.3	0.5	0.2	0.5

Summer catch rates (fish per angler hour) for rainbow trout and kokanee are presented in Table 6. Total catch rates for rainbow trout increased from 0.02 in 1994 to 0.05 in 1995. Kokanee catch rates decreased from 0.15 in 1994 to 0.11 in 1995.

The average length, weight, and condition factor for rainbow trout and kokanee harvested from Hauser Reservoir during 1995 are presented in Table 7. Mean length for rainbow trout (17.5 inches) was at an all-time high. Growing conditions appeared to be good for kokanee--based on a condition factor of 40.5. The mean length and weight for kokanee increased to an all-time high.

Table 6. Catch rates (fish per angler hour) and the percent harvested for rainbow trout and kokanee during the summers of 1986 through 1995 on Hauser Reservoir.

	Rainbow trout				Kokanee			
	Fish/hour			%	Fish/hour			%
Year	Shore	Boat	Total	Kept	Shore	Boat	Total	Kept
1986	0.25	0.26	0.25	88.7	0.01	0.18	0.10	98.6
1987	0.31	0.18	0.24	80.4	0.02	0.24	0.13	92.6
1988	0.38	0.09	0.24	74.8	<0.01	0.38	0.24	93.3
1989	0.21	0.06	0.12	66.2	0.08	0.63	0.42	89.0
1990	0.19	0.05	0.10	89.8	0.02	0.35	0.22	94.0
1991	0.12	0.01	0.02	84.5	0.07	0.53	0.46	94.6
1992	0.12	0.03	0.05	79.5	0.02	0.28	0.22	93.9
1993	0.11	0.02	0.05	91.8	0.02	0.34	0.22	94.6
1994	0.04	0.01	0.02	77.3	<0.01	0.20	0.15	92.4
1995	0.11	0.02	0.05	71.8	0.03	0.14	0.11	86.6
Average	0.18	0.07	0.11	80.5	0.03	0.33	0.23	93.0

Since 1991, kokanee have taken the lead as the species of choice by anglers on Hauser Reservoir (Table 8). Rainbow trout represent the next most frequently targeted species. The OTHER category is predominately comprised of anglers targeting walleye. However, a few anglers do target bass.

New to the creel in 1995 were two questions regarding angler satisfaction for the number and size of fish caught (Table 9). Exactly 63.7% of the anglers interviewed were either unsatisfied or very unsatisfied with the number of fish caught, while 24.9% were satisfied or very satisfied. However, of the anglers who did catch fish, 70.5% were satisfied or very satisfied with the size of the fish (the majority of these being very satisfied). Only 22.1% of the anglers were unsatisfied.

Table 7. Mean length (in), weight (lbs), and condition factors for ainbow trout and kokanee harvested from Hauser Reservoir during the ummers of 1986 through 1995. Ranges are in parentheses.

	RAINBOW TROUT			KOKANEE		
Year	Mean length	Mean weight	Cond. Factor	Mean length	Mean weight	Cond. Factor
1986	13.5 (7.0-20.1)	1.06 (0.14-4.06)	40.1	16.6 (8.5-22.2)	1.87 (0.20-3.94)	39.0
1987	14.2 (7.6-23.0)	1.26 (0.15-4.07)	41.2	15.6 (8.6-21.4)	1.52 (0.32-3.31)	38.2
1988	15.8 (7.9-23.9)	1.73 (0.22-6.00)	40.9	16.3 (8.2-21.8)	1.71 (0.28-3.24)	37.9
1989	13.7 (8.3-22.4)	1.17 (0.22-4.90)	39.1	14.6 (9.2-21.1)	1.13 (0.28-3.10)	35.4
1990	14.9 (7.0-23.5)	1.60 (0.30-4.95)	41.4	15.7 (8.6-23.4)	1.57 (0.26-3.97)	38.5
1991	15.3 (7.4-23.4)	1.74 (0.18-4.90)	41.0	14.7 (8.7-21.2)	1.25 (0.28-3.44)	38.3
1992	15.1 (8.5-24.3)	1.71 (0.31-8.00)	43.6	15.8 (9.4-23.1)	1.67 (0.41-3.27)	41.1
1993	16.3 (8.3-25.3)	1.89 (0.30-5.50)	42.3	16.0 (8.9-21.0)	1.72 (0.32-3.20)	41.3
1994	16.6 (10.1-23.5)	2.04 (0.42-4.02)	39.9	14.8 (10.7-24.8)	1.40 (0.48-4.54)	41.2
1995	17.5 (9.1-23.5)	2.10 (0.30-4.05)	38.5	17.0 (10.0-22.4)	2.04 (0.38-3.45)	40.5

Of the 31 known hatchery-stocked rainbow trout harvested on Hauser Reservoir during the 1995 summer creel, only two were Arlees (one 1+ and one 3+). The other 29 represent DeSmet and Eagle Lake fish that had drifted from Canyon Ferry Reservoir. Length-frequency data as well as hatchery stocking records were used to determine ages on all fish (Table 10).

Table 8. Target species on Hauser Reservoir during the summers of 1986-1995. Data is represented as the percent of total interviews.

Year	RB	Brown	Any Trout	KOK	Trout & KOK	YP	Trout & YP	Other	Any Fish
1986	0.3	0.1	74.9	11.5	0.8	3.1	1.3	0.6	0.7
1987	6.0	0	30.2	14.6	10.3	4.8	3.1	0.2	30.6
1988	1.6	0.1	31.7	11.9	32.1	2.6	0.4	0.1	19.4
1989	1.8	0	27.0	35.8	11.3	5.6	4.8	0.4	13.3
1990	0.5	0	29.3	18.4	38.4	2.9	2.5	0.2	7.8
1991	5.1	0	6.9	69.4	0.5	2.5	0.3	0.2	15.1
1992	12.9	0	4.9	49.5	9.4	7.2	0.9	1.9	13.3
1993	17.5	0	7.1	36.7	9.0	3.0	2.7	0.9	23.1
1994	2.6	0	13.1	46.5	9.1	4.0	3.0	1.0	20.8
1995	10.4	0.4	16.2	43.1	5.4	5.9	0.8	1.8	16.2

Table 9. Results of satisfaction questions on Hauser Reservoir for the summer creel in 1995. Data is represented as the percent of total interviews.

Satisfied with the number of fish		Satisfied with the size of fish	
Very Satisfied	21.3	Very Satisfied	21.8
Satisfied	3.6	Satisfied	2.1
No Strong Opinion	11.4	No Strong Opinion	2.5
Unsatisfied	6.8	Unsatisfied	0.3
Very Unsatisfied	56.9	Very Unsatisfied	7.2
		Not Applicable(No Fish)	66.0

Table 10. Number and age of kokanee and hatchery rainbow trout harvested on Hauser Reservoir during the 1995 summer creel.

SPECIES	0+	1+	2+	3+	4+
Rainbow	0	1	4	7	11
Kokanee	0	4	27	184	0

Winter Creel Census

Yellow perch continued to dominate the catch in the winter ice fishery in 1994/95 (Table 11). Rainbow trout increased in importance to levels not seen since the 1990/91 season. Compared to 1993/1994, kokanee increased from 5.8 to 10.7% of the catch, while yellow perch decreased from 91.1 to 81.7%.

Table 11. Composition of the catch made by anglers on Hauser Reservoir during the winter ice fishery from 1988/89 through 1994/95.

		Percent Composition of Catch				
Year	Number caught	Rainbow Trout	Brown Trout	Kokanee	Yellow Perch	Mountain Whitefish
1988/89	882	29.1	1.8	37.1	31.9	0.1
1989/90	337	27.2	1.4	37.0	34.3	0.1
1990/91	723	9.4	0.7	20.7	69.2	0
1991/92	1177	2.4	0.2	39.0	58.4	0
1992/93	2234	2.6	0.4	33.8	63.1	0.1
1993/94	224	1.8	1.3	5.8	91.1	0
1994/95	624	7.2	0.2	10.7	81.7	0.2

Holter Reservoir

Fish Abundance and Distribution

Floating gill nets. Relative abundance of fish captured in floating gill nets set in Holter Reservoir in 1995 are presented in Table 12. In the spring, rainbow trout, kokanee, and white suckers dominated the catch. In the fall, rainbow trout and kokanee dominated the catch, as they have in every year since 1986 (Appendix Table 3). About 48% of rainbow trout collected in gill nets in 1995 were of hatchery origin.

Catch rates for rainbow trout in floating gill nets in the spring have continued to decline since 1991 (Figure 5). In the fall floating nets, catch rates were substantially higher in 1986

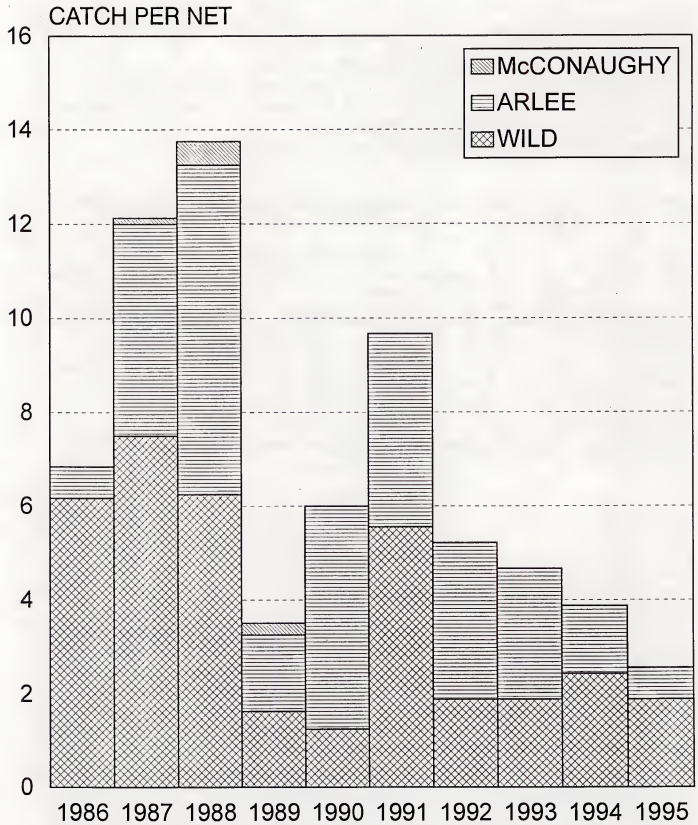

Figure 5. Catch rates for rainbow trout in floating gill nets in Holter Reservoir, Spring 1986-95.

and 1987 than in subsequent years. Since 1988, the fall catch rates have remained fairly stable (Figure 6). Catch rates in fall 1995 were 4.6/net, lower than the 6.9/net in 1994.

Kokanee catch rates in floating nets have shown dramatic changes since 1986 (Figure 7). In the spring nets, catch rates have been very low (0-3 fish/net) in all years except 1991, when the rate was 13.4/net. The catch rate decreased from 3.4/net in 1994 to 0.6/net in 1995. In the fall floating nets, catch rates climbed to a peak in 1990, and dropped slightly every year until 1994, when numbers rebounded to 7.6/net. Catch rates in 1995 jumped to an all-time high with 17.4/net.

Sinking gill nets. Yellow perch, white suckers, and longnose suckers dominated the catch in sinking gill nets in 1995 (Table 12). Numbers for all three species have been holding relatively constant since 1986 (Appendix Table 4). The percentage of yellow perch in the catch in spring 1995 (30.9%) slightly rebounded from the lower number seen in spring 1994 (28.1%). A single burbot was captured in the fall of 1995--the first of this species since netting began in 1986.

The number of walleye captured per sinking gill net was at an all time low in both the spring and fall of 1995 (Table 13). The average length and weight in spring 1995 (22.5 inches and 4.40 pounds) was a record high.

Vertical gill nets. The number of kokanee captured in vertical gill nets increased from 28.5 per net set in 1994 to an all-time high of 85.5 in 1995 (Table 14). This was due primarily to the strength of the age I+ fish, which were caught at a rate of 77.0 fish/net. If the two additional nets (0.5 and 2 inch) are included, the totals were 91.7 and 78.7 fish/net for the total and age 1+ kokanee, respectively (Table 14).

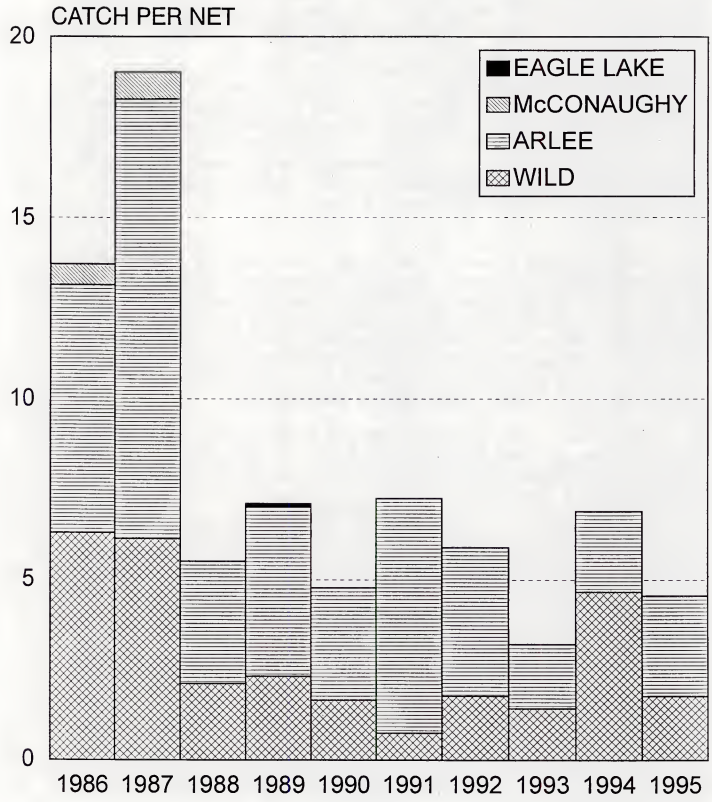

Figure 6. Catch rates for rainbow trout in floating gill nets in Holter Reservoir, Fall 1986-95.

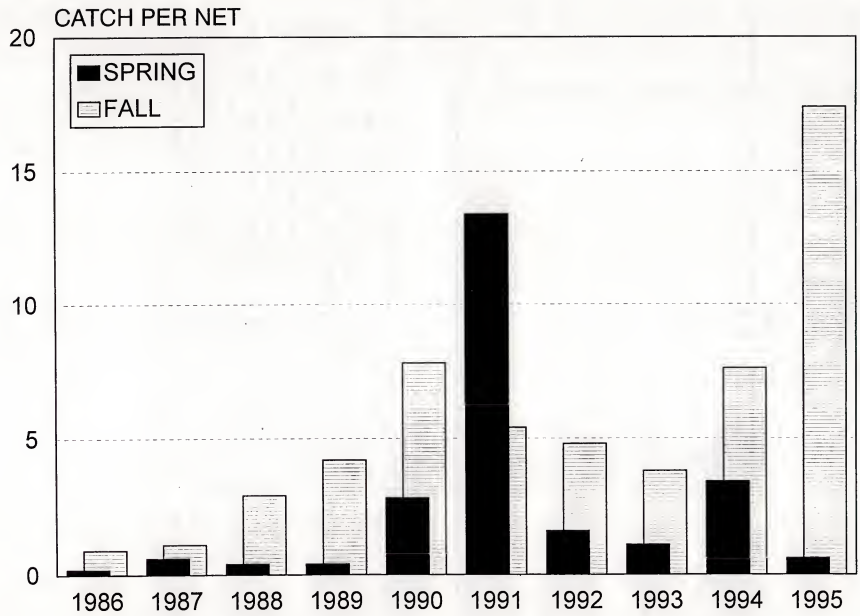

Figure 7. Catch rates for kokanee in floating gill nets in Holter Reservoir, 1986-95.

Table 12. Percent composition by species and season for gill net catches in Holter Reservoir in 1995.

	Sinkers		Floaters	
Species	Spring	Fall	Spring	Fall
RB	2.3	3.9	63.9	20.0
LL	0.6	0	0	0
KOK	1.0	2.1	13.9	76.5
MWF	1.0	0.6	0	0
WE	1.2	0.6	2.8	2.0
YP	30.9	9.0	0	0
LNSU	6.0	12.9	2.8	1.0
WSU	56.6	70.0	16.7	0.5
CARP	0.2	0.8	0	0
UC	0.2	0	0	0
BURBOT	0	0.2	0	0
Total # Caught	514	513	36	205
Number nets	6	6	9	9

Trap netting. Trap nets were fished from April 25 to May 17 in order to capture spawning walleye. A total of 243 walleye were captured during 69 net nights of sampling (Table 15). Sampling effort was concentrated in the Oxbow Bend area, and the majority of the fish were captured in three specific sites on the Bend. Fish were tagged with both red dangler and jaw tags for future tag retention analysis. A total of 192 walleye were tagged for the first time, and had a spine and scale removed for ageing. The remaining 51 fish had been previously tagged--19 fish had been tagged earlier in 1996 and 32 fish had been tagged in previous years. Other species of fish caught in the nets, in decreasing order of abundance, were white sucker (5,548), yellow perch (1,558), and rainbow trout (347).

Table 13. Number of fish per net night and mean length, weight and condition factors for walleye collected in sinking gill nets set in Holter Reservoir from 1986 through 1995. Ranges are in parentheses.

Year	Number Per Net	Mean Length (in)	Mean Weight (lbs)	Mean Condition Factor
		SPRING		
1986	--	--	--	--
1987	2.60	12.2 (9.5-16.6)	0.70 (0.22-1.69)	31.3
1988	2.17	19.1 (11.0-27.9)	3.00 (0.40-8.00)	33.8
1989	2.50	19.6 (17.2-27.0)	2.70 (1.55-7.50)	33.1
1990	2.40	19.1 (12.3-24.6)	3.22 (0.55-6.25)	38.6
1991	2.17	15.7 (11.7-26.3)	1.75 (0.51-7.00)	34.5
1992	2.50	20.7 (12.3-30.6)	3.29 (0.66-9.40)	35.5
1993	2.33	19.2 (12.1-28.3)	2.98 (0.58-7.00)	35.6
1994	4.83	20.5 (10.6-28.5)	3.73 (0.38-8.75)	35.7
1995	1.00	22.5 (16.3-28.3)	4.40 (1.62-7.75)	35.5
		FALL		
1986	2.33	20.0 (15.0-30.0)	3.31 (1.12-10.0)	35.8
1987	3.17	16.7 (9.7-26.2)	2.05 (0.26-8.00)	36.7
1988	1.33	19.6 (15.6-25.4)	2.87 (1.52-5.00)	36.7
1989	4.33	20.5 (13.3-29.1)	3.60 (0.78-8.60)	37.9
1990	2.33	21.2 (13.5-27.2)	3.97 (0.84-9.00)	37.5
1991	2.83	20.4 (11.5-26.0)	4.08 (0.44-9.10)	40.7
1992	3.67	22.4 (12.0-27.5)	4.12 (0.66-6.80)	37.3
1993	4.00	22.0 (15.1-27.5)	4.67 (1.30-9.25)	40.3
1994	1.43	21.2 (15.3-27.0)	4.20 (1.19-7.30)	39.3
1995	0.50	16.4 (11.8-25.4)	2.82 (0.51-7.25)	38.3

Table 14. Mean catch rates (fish per net night) by age class for kokanee collected in vertical nets set at the Dam Station in Holter Reservoir from 1986 through 1995. Length-frequency analysis was used to age fish in 1995.

Year	Number of sets	Number of kokanee per set				
		Age 0+	Age 1+	Age 2+	Age 3+	Total
1986	3	0	4.0	2.3	1.0	7.3
1987	4	0	3.0	3.0	0.5	6.5
1988	6	0	2.8	1.7	0.7	5.2
1989	5	0	9.2	4.2	0.4	13.8
1990	6	0	4.0	9.0	0.7	13.7
1991	5	0	2.2	11.2	2.0	15.5
1992	7	0	6.3	2.6	2.1	11.0
1993	6	0.2	15.2	3.3	0.3	19.2
1994	4	0	21.0	4.0	3.5	28.5
1995	6	0	77.0	5.2	3.3	85.5
1995[a]	6	0.7	78.7	6.2	6.2	91.7

[a]Includes two additional nets - 0.5 and 2.0 inch mesh for a total of six vertical nets/night.

The progression of walleye spawning activity was evident from the trap-netting data. The first ripe female was not observed until May 7, and the first spent female was captured on May 15. The peak daily catch for walleye (35) occurred on May 16, when temperatures were 46-48°F. Three spent females were captured on May 16, but this represented only 30% of the females that day. Of the 13 females captured on the last day (May 17), three were gravid and ten were ripe. These findings suggest that walleye spawning had not yet peaked when we last sampled on May 17. Trap results in 1995 support this belief, because spawning in that year started to peak only when temperatures rose above 50° F. By comparison, the highest water temperature for the 1996 trap netting effort was only 48°F.

The spawning activity for yellow perch began earlier than for walleye. No spent females were captured until the second day

(April 26) of sampling. Spawning continued throughout the sampling period, and there was a clear trend toward a greater percentage of spent fish as time progressed. The yellow perch spawn started to peak around April 30 when daily water temperatures reached a minimum of 44°F. Unquantified observations suggested that the number of egg masses along the shorelines and in the nets also peaked at about this time. The yellow perch numbers were far fewer than in 1995 (1,558 vs. 3,279). This is consistent with gill netting and creel data which suggests a reduced yellow perch population.

Table 15. Numbers and species of fish captured in trap nets in Holter Reservoir, 1996. Temperature ranges are based on water surface measurements taken periodically during the day.

			Number of fish			
Date of set	Number nets	Temp. Range (°F)	walleye	yellow perch	rainbow trout	white sucker
4/25	5	42-48	1	161	48	183
4/26	4	43-48	5	130	29	167
4/30	5	44-46	11	189	24	284
5/1	5	44-47	4	221	12	289
5/2	5	44-48	11	203	12	342
5/3	5	44-48	8	139	7	198
5/7	5	45-47	8	85	24	396
5/8	5	45-47	33	95	51	654
5/9	5	44-45	22	110	38	142
5/10	5	43-44	8	93	36	112
5/14	5	46-47	29	20	19	709
5/15	5	46-47	34	47	20	613
5/16	5	46-48	35	39	14	808
5/17	5	46-48	34	26	13	651
Total			243	1,558	347	5,548

Walleye tagging. Walleye have been tagged with dangler tags since 1988 in an effort to estimate angler harvest. A total of 282 walleye were tagged in 1995, bringing the total number of tagged fish to 667 (Table 16). Five of the fish tagged in 1995 were returned by anglers that year and four tags were returned from fish tagged in 1988, 1989 and 1990. It is important to note that six of the nine tag returns in 1995 were from walleye caught below Holter Dam.

The percentage of tagged fish being caught by anglers has been quite variable (Table 16). This variability is probably due to the small sample size of tagged fish. Probably the only years when enough fish were tagged to yield reliable estimates of harvest are 1988,1990 and 1995, when 92, 121 and 282 fish were tagged, respectively. Tagging efforts in conjunction with trap netting (as occurred in spring 1995/96) should provide for larger numbers of tagged fish and yield more accurate harvest estimates.

Table 16. Number of walleye tagged and caught by anglers on Holter Reservoir, 1988-1995.

Year tagged	Number tagged	Number (percent of total) of tagged walleye harvested by anglers								
		1988	1989	1990	1991	1992	1993	1994	1995	Cumulative
1988	92	4(4.3)	1(1.1)	0(0.0)	0(0.0)	2(2.2)	3(3.3)	0(0.0)	1(1.1)	11(12.0)
1989	31		2(6.5)	1(3.2)	0	0	0	0	1(3.2)	4(12.9)
1990	121			1(0.8)	2(1.7)	3(2.5)	2(1.7)	2(1.7)	2(1.7)	12 (9.9)
1991	63				0	1(1.6)	1(1.6)	1(1.6)	0	3 (4.8)
1992	42					2(4.8)	0	0	0	2 (4.8)
1993	18						0	2(11.1)	0	2(11.1)
1994	18							0	0	0 (0.0)
1995	282								5(1.8)	5 (1.8)

Beach Seining. Numbers of forage fish captured per tow in 1995 are shown in Table 17. Sucker and yellow perch numbers decreased from 1994. Walleye numbers showed a slight increase.

Table 17. Number of fish/tow in Holter Reservoir 1990-1995.

YEAR	NUMBER OF TOWS	Y. PERCH TOTAL	SUCKER TOTAL	WALLEYE TOTAL
1990	7	125.1	N/A	0
1991	20	274.2	N/A	2.5
1992	20	622.2	147.2	0
1993	20	38.0	52.5	<0.1
1994	19	169.7	288.6	0
1995	16	80.3	120.9	1.0

Summer Creel Census

A total of 800 anglers were interviewed on Holter Reservoir during the summer period (April through October) in 1995. As with the previous year, the interviews were done almost exclusively during the weekends. Distribution of interviews, hours per fishing trip and mean number of anglers per fishing party are presented in Table 18.

The composition of the catch made by anglers during the summer of 1995 is presented in Table 19. Yellow perch numbers fell to an all-time low, comprising only 28.3% of the catch. The catch for kokanee in 1995 (11.6%) was similar to every other year since 1990, the first year that kokanee comprised over 10% of the catch. Rainbow trout numbers rebounded and comprised 59.1% of the catch, the highest ever since 1986.

Table 18. Distribution of interviews by day of week and by method of fishing with mean hours per completed fishing trip and mean party size obtained on Holter Reservoir during the summers of 1986 through 1995.

	PERCENT OF TOTAL INTERVIEWS					
YEAR	WEEKDAY	WEEKEND	SHORE	BOAT	MEAN HOURS FISHED/TRIP	MEAN # OF ANGLERS/PARTY
1986	25	75	34	66	3.88	2.43
1987	34	66	41	59	4.02	2.23
1988	44	56	40	60	4.54	2.17
1989	38	62	41	59	4.13	2.10
1990	35	65	40	60	4.08	2.21
1991	42	58	48	52	4.02	2.17
1992	45	55	26	74	4.19	2.50
1993	52	48	39	61	3.83	2.50
1994	1	99	24	76	4.32	2.93
1995	8	92	31	69	4.12	2.66
OVERALL	32	68	36	64	4.11	2.39

Annual summer catch rates (fish per angler hour) for rainbow trout and yellow perch are presented in Table 20. The catch rates for rainbow trout in 1995 (0.16/hr) were higher than in 1994 (0.03), but lower than the overall average (0.24). Catch rates for yellow perch decreased from 0.34/hr in 1994 to an all-time low of 0.08/hr in 1995. The angler catch rate for kokanee was 0.06/hr in 1994 and decreased slightly to 0.03/hr in 1995. Catch rates for anglers specifically seeking to catch walleye were 0.11/hr in 1994, decreasing to <0.01/hr in 1995.

Table 19. Composition of the catch by anglers on Holter Reservoir during the summers of 1986 through 1995.

		PERCENT COMPOSITION OF CATCH					
YEAR	NUMBER CAUGHT	RAINBOW TROUT	BROWN TROUT	KOKANEE	YELLOW PERCH	MOUNTAIN WHITEFISH	WALLEYE
1986	1,893	67.5	0.3	1.0	30.9	<0.1	0.3
1987	4,339	46.3	0.1	1.8	49.6	<0.1	2.2
1988	2,968	45.0	0.2	1.8	52.2	0	0.8
1989	4,848	23.7	<0.1	0.7	75.2	0	0.4
1990	5,109	28.5	0	12.5	58.5	0	0.5
1991	4,223	34.9	<0.01	12.5	52.0	0.2	0.4
1992	6,823	26.3	<0.1	11.3	61.8	<0.1	0.6
1993	1,828	32.1	0.1	14.8	52.8	<0.1	0.2
1994	2,098	7.1	0.1	13.2	77.3	<0.1	2.3
1995	760	59.1	0.1	11.6	28.3	0	0.9

Table 20. Catch rates (fish per angler hour) and the percent harvested for rainbow trout and yellow perch during the summers of 1986 through 1995 on Holter Reservoir.

	RAINBOW TROUT (NO/HR)				YELLOW PERCH (NO/HR)			
YEAR	SHORE	BOAT	TOTAL	% KEPT	SHORE	BOAT	TOTAL	% KEPT
1986	0.27	0.37	0.34	81.8	0.30	0.10	0.16	91.3
1987	0.24	0.41	0.37	85.9	0.61	0.31	0.39	72.7
1988	0.19	0.38	0.32	81.8	0.70	0.22	0.37	76.2
1989	0.22	0.29	0.27	70.8	0.40	1.06	0.85	83.1
1990	0.27	0.25	0.26	67.8	0.48	0.55	0.53	65.7
1991	0.36	0.19	0.27	78.1	0.31	0.47	0.40	76.3
1992	0.19	0.23	0.22	76.6	0.52	0.52	0.52	76.8
1993	0.21	0.10	0.14	87.7	0.18	0.24	0.22	90.3
1994	0.02	0.03	0.03	88.0	0.41	0.33	0.34	89.9
1995	0.30	0.12	0.16	52.3	0.22	0.04	0.08	26.5
OVERALL	0.23	0.24	0.24	77.1	0.41	0.38	0.39	74.9

The average length, weight and condition factor for rainbow trout and kokanee harvested from Holter Reservoir during 1995 are presented in Table 21. Rainbow trout decreased slightly in length (14.1 in) and weight (1.31 lbs) from the previous year. Over the years a comparison of netting and creel data have indicated that Arlee rainbow trout stocked into Holter Reservoir are more susceptible to being caught by anglers than wild rainbow trout. This is what was seen in 1994, where 68% of harvested rainbow trout were of hatchery origin, while only 34% of horizontal and vertical gillnetted fish were of hatchery origin. This was not seen in 1995 when about 53% of harvested rainbow trout were of known hatchery origin, while 59% of gillnetted fish were of hatchery origin.

Kokanee started to gain in importance as a target species for anglers as early as 1990 (Table 22). Since 1991 kokanee have become a major component as a target species by anglers. The OTHER category is made up almost exclusively of anglers targeting walleye.

Table 21. Mean length (in), weight (lbs), and condition factors for rainbow trout and kokanee harvested from Holter Reservoir during the summers of 1986 through 1995. Ranges are in parentheses.

	RAINBOW TROUT			KOKANEE		
YEAR	MEAN LENGTH	MEAN WEIGHT	COND. FACTOR	MEAN LENGTH	MEAN WEIGHT	COND. FACTOR
1986	13.9 (8.1-20.8)	1.17 (0.2-4. 4)	40.8	16.9 (14.3-20.1)	2.17 (1.4-3.0)	43.4
1987	13.8 (7.5-22.2)	1.11 (0.2-3.7)	41.0	16.7 (10.1-21.0)	2.01 (0.4-3.8)	41.9
1988	13.7 (7.5-20.8)	1.17 (0.2-3.3)	41.6	16.8 (13.0-23.2)	1.96 (0.9-4.0)	42.2
1989	14.5 (8.9-21.3)	1.26 (0.3-2.9)	39.7	16.1 (14.1-19.5)	1.99 (1.3-3.6)	43.8
1990	14.2 (8.0-20.1)	1.17 (0.2-3.7)	39.1	16.1 (11.7-21.0)	1.79 (0.6-3.9)	42.1
1991	12.6 (8.1-24.5)	0.83 (0.3-5.0)	37.9	15.2 (9.7-20.2)	1.63 (0.4-3.1)	44.1
1992	14.1 (8.2-19.8)	1.20 (0.2-3.7)	41.5	16.6 (9.5-23.2)	2.08 (0.4-3.6)	44.4
1993	15.9 (9.0-24.3)	1.76 (0.1-6.0)	41.9	16.1 (12.2-21.9)	1.99 (0.8-3.9)	46.7
1994	14.7 (10.0-21.2)	1.32 (0.5-2.7)	39.9	16.2 (10.5-22.0)	1.93 (0.5-4.2)	44.5
1995	14.1 (6.0-23.0)	1.31 (0.2-4.2)	41.8	15.7 (8.8-20.7)	1.89 (0.3-3.7)	43.2

Table 22. Target species on Holter Reservoir during the summers of 1986-1995. Numbers represent the percent of total interviews.

YEAR	RB	BROWN	ANY TROUT	KOK	TROUT & KOK	YP	TROUT & YP	OTHER	ANY FISH
1986	0.1	0	84.9	0.1	0.3	5.8	3.0	1.3	4.5
1987	7.9	0	44.5	1.2	2.6	12.3	3.1	4.9	23.5
1988	2.5	0	39.1	3.1	10.2	13.2	1.8	3.5	29.5
1989	9.2	0	44.3	0.6	7.3	17.1	4.8	1.8	14.9
1990	0.6	0	41.9	4.4	21.9	14.0	4.0	4.8	8.5
1991	15.3	0	18.7	16.0	11.2	11.4	2.9	2.3	22.3
1992	18.6	0	6.2	22.3	18.8	13.0	3.3	4.1	13.7
1993	19.9	0	5.9	17.7	16.2	11.4	3.7	2.8	22.3
1994	1.7	0	9.1	23.5	20.1	15.0	3.3	7.4	19.8
1995	7.6	0	20.1	18.0	17.4	8.4	1.9	7.6	19.0

New to the creel in 1995 were two questions regarding angler satisfaction for the number and size of fish caught (Table 23). Of the anglers interviewed, 68.6% were unsatisfied with the number of fish caught while 19.9% were satisfied. Slightly more anglers who caught fish were satisfied (49.3%) with the size of the fish caught than were unsatisfied (39.4%).

Table 23. Results of the satisfaction questions on Holter Reservoir for the summer creel in 1995. Data is represented as the percent of total interviews.

SATISFIED WITH THE NUMBER OF FISH		SATISFIED WITH THE SIZE OF FISH	
Very Satisfied	15.7	Very Satisfied	14.2
Satisfied	4.2	Satisfied	2.3
No Strong Opinion	11.5	No Strong Opinion	3.8
Unsatisfied	8.1	Unsatisfied	2.6
Satisfied	60.5	Satisfied	10.6
		Not Applicable(No Fish)	66.5

Of the 105 known hatchery-stocked rainbow trout harvested on Holter Reservoir during the 1995 summer creel all but two were Arlees. These two fish had drifted from Canyon Ferry Reservoir (one 4+ DeSmet and one 3+ Eagle Lake). Length-frequency data as well as hatchery stocking records were used to age all fish (Table 24).

Table 24. Ages of kokanee and hatchery rainbow trout harvested on Holter Reservoir during the 1995 summer creel.

SPECIES	0+	1+	2+	3+	4+
Rainbow	0	7	74	23	1
Kokanee	0	2	24	19	0

Winter Creel Census

As in previous years, yellow perch dominated the composition of the catch during the winter of 1994/95 (Table 25). Harvested rainbow trout averaged 15.0 inches in length, while yellow perch averaged 9.4 inches. Catch rates for rainbow trout and yellow perch were 0.04/hr and 0.45/hr, respectively. The catch rates for rainbow trout were similar to the winter of 1993/94. The yellow perch catch rates decreased from 3.79/hr in 1993/94 to 0.45/hr in 1994/95.

Table 25. Composition of the catch made by anglers on Holter Reservoir during the winter ice fishery from 1988/89 through 1994/95.

		PERCENT COMPOSITION OF CATCH				
YEAR	NUMBER CAUGHT	RAINBOW TROUT	BROWN TROUT	KOKANEE	YELLOW PERCH	MOUNTAIN WHITEFISH
1988/89	4704	7.3	<0.1	0	92.3	0.4
1989/90	3597	7.2	0	<0.1	92.6	0.2
1990/91	6162	6.9	0	0.4	92.4	0.3
1991/92	2930	3.9	0	<0.1	96.0	0
1992/93	4487	3.3	0	<0.1	96.6	0
1993/94	393	17.0	0	0.5	82.4	0
1994/95	72	25.0	0	0	75.0	0

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Rada, R.G. 1974. An investigation into the trophic status of Canyon Ferry Reservoir, Montana. PhD Thesis. Montana State University, Bozeman, MT. 126 pp.

Prepared by: Troy Humphrey and Don Skaar
Date: January 1997
Waters referred to:

Hauser Reservoir	17-9056
Holter Reservoir	17-9136

APPENDICES

Appendix Table 1. Percent composition by species and season for floating gill net catches in Hauser Reservoir from 1986 through 1994.

	1986		1987		1988		1989		1990	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB	29.0	31.3	9.7	44.2	17.7	42.0	13.2	20.9	5.4	16.5
LL	0.2	2.5	1.3	1.2	0.6	1.4	2.0	0.9	1.6	0.5
KOK	2.9	57.3	36.0	25.1	71.3	47.9	74.2	73.2	88.6	79.3
MWF	0.2	4.3	0	0	1.2	0.9	0	0.3	0	0.7
WE	0	0	0	0	0	0	0	0	0	0
YP	0	0.7	0	0	0	0	0	0	0	0
LNSU	52.9	1.4	35.8	12.9	6.1	2.5	5.3	0.9	1.6	0.2
WSU	13.8	1.1	16.4	16.0	3.1	0.5	5.3	0.3	2.7	0.2
CARP	0.5	0	0	0	0	0	0	0	0	0
U.CHUB	0.5	1.4	0.8	0.6	0	4.8	0	3.5	0	2.5
TOTAL # CAUGHT	448	281	383	163	164	438	151	339	185	401
NUMBER OF NETS	9	11	10	11	10	11	9	11	11	11

	1991		1992		1993		1994	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB	7.8	8.1	12.7	15.0	17.2	17.7	7.0	17.6
LL	0.7	0.7	3.0	0.3	1.6	0.5	2.0	1.1
KOK	85.6	70.0	47.6	81.5	68.0	76.3	56.1	54.0
MWF	0.4	0.5	0	0.6	0	0.5	0	0.5
WE	0	0.5	1.1	0	0.4	0	0.4	0
YP	0	0	0	0	0.4	0	0.4	0
LNSU	1.8	0	10.9	0.3	2.5	0	20.9	14.4
WSU	1.5	0	24.3	0.9	9.0	1.0	12.7	12.3
CARP	0	0	0.4	0	0	0	0	0
U.CHUB	2.2	20.2	0	1.4	0.8	4.5	0.1	0
TOTAL # CAUGHT	271	420	267	346	122	198	244	187
NUMBER OF NETS	11	11	11	11	9	11	11	11

Appendix Table 2. Percent composition by species and season for sinking gill net catches in Hauser Reservoir from 1986 through 1994.

	1986		1987		1988		1989		1990	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB		0.7	0.2	1.4	0	0.5	0	1.8	0	0.3
LL		1.0	1.5	0.4	1.2	0.5	0.9	0	0.7	0.7
KOK		0.4	1.1	4.2	4.2	9.1	1.7	18.3	2.7	11.1
MWF		3.6	3.8	2.3	5.4	2.6	2.4	0.5	2.0	2.1
WE		0	0	0	0	0	0.2	0	0	0
YP		4.9	4.7	9.3	10.6	4.3	5.8	3.5	13.5	3.8
LNSU		28.9	23.0	16.1	17.9	24.1	22.3	14.7	19.5	16.1
WSU		60.5	65.5	66.0	60.0	58.3	66.0	59.4	58.4	63.4
CARP		0	0	0	0	0	0	0.2	0	0
U.CHUB		0	0.2	0.1	0.5	0.1	0.3	1.3	3.1	2.3
BURBOT		0	0	0.2	0	0.5	0.2	0	0	0.2
S.BUFF.		0	0	0.2	0	0.5	0.2	0	0	0
TOTAL # CAUGHT	0	700	473	839	407	648	574	600	548	577
NUMBER OF NETS	0	5	5	6	6	6	6	6	6	6

	1991		1992		1993		1994	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB	0	0.7	0	0.7	0	0.2	0.4	0.4
LL	1.2	0.4	0.2	1.0	2.6	1.0	3.0	0.9
KOK	3.1	20.6	0.7	7.7	11.5	6.8	7.0	4.0
MWF	3.0	1.7	1.7	1.2	2.0	1.6	1.5	0.9
WE	0	0.6	0.7	0.1	0	0.2	0.7	0.2
YP	13.7	11.2	21.5	8.1	17.1	10.7	12.9	7.4
LNSU	20.9	16.6	19.6	18.3	23.5	18.7	31.4	12.0
WSU	55.7	45.0	53.3	59.3	40.8	57.3	39.9	45.1
CARP	0	0	0	1.0	0	0	0	29.1
U.CHUB	1.9	1.7	0	1.8	0.8	1.4	2.6	0.7
BURBOT	0.2	0.4	2.1	0.7	1.8	1.2	0.7	0.2
S.BUFF	0.3	1.1	0.2	0	0	1.0	0	0
TOTAL # CAUGHT	635	705	424	765	392	513	271	902
NUMBER OF NETS	6	7	6	7	6	7	6	7

Appendix Table 3. Percent composition by species and season for floating gill net catches in Holter Reservoir from 1986 through 1994.

	1986		1987		1988		1989		1990	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB	25.5	77.2	47.1	76.6	64.3	41.5	25.0	52.1	61.5	34.7
LL	0	0.8	1.6	2.2	1.2	1.9	0	0.9	1.3	0
KOK	0.6	4.9	2.6	4.8	1.7	21.7	2.7	33.0	28.2	56.5
MWF	2.5	3.3	1.6	0	1.2	2.8	0.9	0.9	0	1.6
WE	5.0	9.7	7.4	0.5	4.1	0	1.8	2.6	5.1	0
YP	0	0	20.1	0	18.7	0	8.9	0	0	0
LNSU	40.4	3.3	10.1	6.9	4.1	12.3	38.4	7.0	1.3	6.5
WSU	24.8	0.8	7.9	9.0	3.5	19.8	22.3	2.6	2.6	0.8
CARP	1.2	0	1.6	0	1.2	0	0	0	0	0
U.CHUB	0	0	0	0	0	0	0	0.9	0	0
TOTAL # CAUGHT	161	123	189	188	171	106	112	115	78	124
NUMBER OF NETS	6	7	8	8	8	8	8	9	8	9

	1991		1992		1993		1994	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB	34.5	53.7	39.2	35.3	26.1	42.0	34.0	42.5
LL	0	1.9	0	1.3	0	0	0	0.7
KOK	46.9	39.8	11.7	28.6	6.2	49.3	30.1	46.6
MWF	1.2	2.8	3.3	0	0	0	1.0	1.4
WE	13.9	0	0.8	0.7	3.7	2.9	5.8	0
YP	0	0	38.3	0	29.8	0	14.6	0
LNSU	0.4	0.9	0	20.0	8.1	1.4	7.8	2.7
WSU	2.7	0.9	5.8	14.0	26.1	4.3	4.9	6.2
CP	0.4	0	0.8	0	0	0	1.9	0
U.CHUB	0	0	0	0	0	0	0	0
TOTAL # CAUGHT	258	108	120	150	161	69	103	146
NUMBER OF NETS	9	8	9	9	9	9	9	9

Appendix Table 4. Percent composition by species and season for sinking gill net catches in Holter Reservoir from 1986 through 1994.

	1986		1987		1988		1989		1990	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB		4.3	0.9	2.5	1.4	2.6	1.1	1.8	1.0	3.1
LL		0.2	0.8	0.3	0.2	0	0.2	0	0.7	0
KOK		0.4	0	0.2	0.3	0.5	0	0.6	0	1.9
MWF		1.8	1.7	2.0	3.6	0.5	5.1	1.8	4.0	4.3
WE		2.5	1.6	3.1	2.0	1.3	2.8	5.2	2.0	2.9
YP		24.0	57.2	28.8	34.0	21.8	29.5	10.6	39.2	16.0
LNSU		24.0	16.5	21.5	17.6	21.9	11.2	20.4	11.4	15.4
WSU		42.8	21.2	41.6	40.7	51.2	49.7	59.6	41.4	56.2
CARP		0	0.1	0	0	0.2	0.4	0	0	0.2
U.CHUB		0	0	0	0.2	0	0	0	0.3	0
TOTAL # CAUGHT	0	551	838	601	658	611	545	500	597	486
NUMBER OF NETS	0	6	5	6	6	6	6	6	5	6

	1991		1992		1993		1994	
SPECIES	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
RB	0.7	4.4	0.2	0.8	0.4	1.5	0.5	2.7
LL	0.1	0	0.1	0.2	0	0.2	0	0
KOK	0.6	1.6	0.1	1.4	0.1	1.5	0.2	1.2
MWF	5.8	1.3	1.8	2.2	1.5	1.5	2.0	0.2
WE	1.4	3.0	1.6	4.2	1.9	6.0	5.3	2.4
YP	50.4	11.3	43.4	21.5	42.3	9.4	28.1	10.0
LNSU	11.9	20.3	5.4	15.5	10.4	17.0	12.8	23.4
WSU	29.1	58.1	46.9	53.8	43.2	62.3	51.0	60.0
CP	0	0	0.3	0.4	0.1	0.5	0.2	0
U.CHUB	0	0	0	0	0.1	0	0	0
TOTAL # CAUGHT	894	566	921	502	743	401	549	410
NUMBER OF NETS	6	6	6	6	6	6	6	6

PART B

FLUSHING LOSSES OF HATCHERY RAINBOW TROUT FROM THREE MID-MISSOURI RIVER RESERVOIRS

ABSTRACT

Fisheries data from 1969-1972 and 1986-1995 were analyzed in order to characterize the temporal and spatial patterns of flushing of hatchery rainbow trout from Canyon Ferry, Hauser and Holter reservoirs. With respect to the 1986-1995 period, relatively high levels of flushing were observed in 1986, 1993 and 1995, which were also relatively high years in terms of quantity of water discharged from the dams. Relatively low flushing rates were found in 1988 and 1992, which were also low years for dam discharge. Retention of hatchery fish in Hauser and Holter Reservoirs (as measured by gill net catch rates) was negatively correlated to quantity of dam discharge, and partial correlation analysis suggested that both spill and turbine discharge are responsible for flushing losses. Flushing losses over the spillways were also evidenced by creel surveys which showed that the numbers of hatchery fish in the river below the dams increased substantially during periods of spill. During periods when spillways were not used, the presence of hatchery fish in the tailraces of Canyon Ferry and Holter Dams were proof that fish are flushed (entrained) through the turbines. At Canyon Ferry Dam, turbine entrainment of trout probably occurred even when penstock intakes were deeper than 80 feet. Seasonal shifts in the vertical distribution of hatchery fish in the reservoirs were hypothesized to affect flushing rates. In some years, changes in catch rates of hatchery fish in the tailwaters of Canyon Ferry and Holter dams were believed to be a reflection of these shifts. The annual contribution of Canyon Ferry hatchery rainbows to the Hauser Reservoir creel for the years 1986-1995 was estimated to be 2.1%, much higher than the 0.2% annual contribution rate of Canyon Ferry and Hauser rainbows to the Holter Reservoir creel. The contribution of Canyon Ferry fish to Hauser was greatest in 1995, when an estimated 1,512 Canyon Ferry rainbows were caught in Hauser Reservoir. Creel surveys and electrofishing were used to demonstrate that when hatchery fish are flushed out of Holter Reservoir, they reside almost exclusively in the first 2.5 miles of river below the dam.

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INTRODUCTION

This report summarizes work that was conducted from 1969-1972 and 1986-1995 to quantify the movement of hatchery rainbow trout through and over Canyon Ferry, Hauser and Holter dams. The early work was a series of experiments designed to quantify the timing and magnitude of flushing (the term "flushing" used here to refer to any route of passage past the dams--including turbines, gates or spillways). The early work used albino rainbow trout or trout marked with fin clips or jaw tags. The recent work (1986-1995) has emphasized the collection of data to evaluate performance of individual strains of rainbow trout. Because each strain of rainbow trout was marked in a unique way (fluorescent spray-mark pigments, fin clips, tetracycline-induced marks on the vertebrae), we are able to use these data to describe and quantify certain aspects of fish flushing.

DAM OPERATIONS AND VERTICAL FISH DISTRIBUTION

As a basis for explaining differences in flushing rates, it is necessary to understand dam operations, the physical layout of penstocks and spillways, thermal characteristics of the reservoirs, and the distribution of fish near the dams.

Dam Operations

Canyon Ferry Dam

Missouri River water first enters Canyon Ferry Reservoir just north of Townsend (Figure 1). The reservoir is 25 miles in length, with a surface area of 35,153 acres and a maximum depth of 164 feet. At Canyon Ferry Dam, the three turbine penstock intakes are 13.5 feet in diameter, the tops of which are 84 feet below the water surface when the reservoir is at full pool (3,797 ft msl). There is also a penstock which diverts water for the Helena Valley Irrigation System. It is 13 feet in diameter, with the top being 100 feet below full pool. This penstock delivers water to a pump station on the downstream side of the dam. From the station, water is either pumped away from the river and into the Helena Valley, or run through a turbine and back into the river. Other portals through Canyon Ferry Dam include four river gates, which are 77 inches in diameter and the tops of which are 130 feet below full pool. When water is spilled, radial gates swing open from a depth of 31 feet, and very rarely will open up more than two feet--to a depth of 29 feet. Dam operations are perhaps most easily characterized by describing conditions under three flow scenarios. In a dry year such as 1992 (61% of normal flow), the lowest water surface elevation was in March at 16 feet below full pool, and the highest elevation was in July at 10 feet below full pool. The spillway was not used at all in 1992. In a wetter year such as 1986 (98% of normal flow), low elevation was 15 feet below full pool in March, but the reservoir did fill during June. Spilling occurred only briefly from June 6-18. In the wet year of 1995 (121% of normal flow), low elevation was 14 feet below full pool from January through the end of May, then rose to full pool in June and remained full through July. Spilling lasted from May 12 to June 23 and again from July 5 to 24.

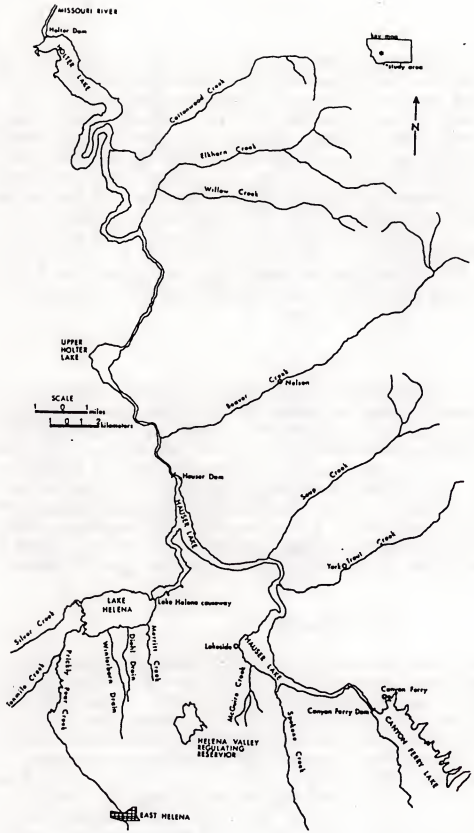


Figure 1. Map of Canyon Ferry, Hauser and Holter reservoirs.

Hauser Dam

Water from Canyon Ferry discharges into Hauser Reservoir, which at full pool impounds water to the base of Canyon Ferry Dam. The reservoir is 15.5 miles in length with a surface area of 3,798 acres and a maximum depth of 69 feet. Hauser Dam is operated as a run-of-the-river facility, with the pool elevation rarely dropping more than 1-2 feet below full pool. It has the lowest powerhouse capacity of the three dams, and therefore spills more water than the other dams. Turbine water first enters a 32-foot deep intake channel on the east side of the dam. The six penstock intakes draw from this channel, with the openings being from 16 to 30 feet below full pool. When spilling occurs, the first five gates to be operated are hydraulic, which withdraw water from 8-14 feet below full pool. Additional spill comes from another 17 manually-operated gates which withdraw from 0-14 feet below full pool. Even in a very dry year such as 1992, spilling occurred through much of January, February and March and then again during two days in May. In 1986, spilling occurred during 90% of the days of the year, but the greatest volume of spill was during June. In 1995, a wet year, spilling occurred through much of February and March and then from April 6 to the end of the year.

Holter Dam

There is a 3.5-mile stretch of free-flowing river between Hauser Dam and the upper end of Holter Reservoir. The reservoir is managed as a run-of-the-river facility with the water surface rarely being dropped more than two feet from full-pool elevation. The reservoir is 25 miles long, with a surface area of 4,800 acres and a maximum depth of 121 ft. At Holter Dam, the penstock intakes are from 20 to 34 feet below full pool. In addition, an "exciter" unit is always operating, which has its penstock opening from 25 to 29 feet below full pool. When spilling, depth of withdrawal is from 6-16 feet. In very high flow situations, a "cap" can be removed from the spill gates and the top six feet of the water column can be spilled as well. In a dry year (1992), Holter spilled only one day (October 13). In a more normal water year (1986), spilling occurred from June 4 to July 7. In the wet year (1995), spilling extended from April 12-July 27 and again for 15 days in August and September.

Vertical Fish Distribution

The vertical distribution of hatchery rainbow trout was determined by fishing vertical gill nets at sites which were located about 1.5, 0.25 and 2.0 miles above Canyon Ferry, Hauser, and Holter dams, respectively. The nets were 150 feet deep by 12 feet wide (3/4- 1-, 1½-, and 2-inch mesh sizes) and were fished monthly from April through November. Net catches showed that the trout occupied shallow waters during the entire period, but also selected deeper water during the summer (Figures 2-4). However, differences between the reservoirs did exist. Holter has the best data set, and it shows that fish primarily occupy water shallower than 12 feet in May and 22 feet in June before moving to much deeper water in July (40-50 feet). The fish are found in depths up to 60-70 feet in August and September, then move back to the top 50 feet in October and the top 15 feet in November. Fish generally occupied shallower water in Hauser than in Holter. Maximum depth for

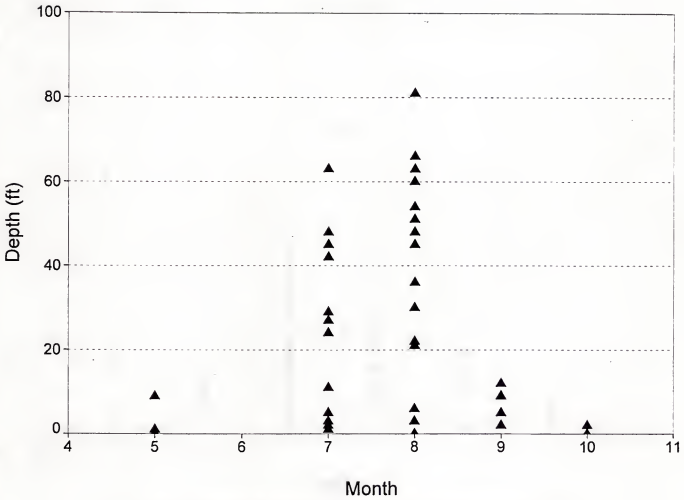


Figure 2. Catches of hatchery rainbow trout in vertical gill nets in Canyon Ferry Reservoir, 1986-1991. Each traingle represents one fish.

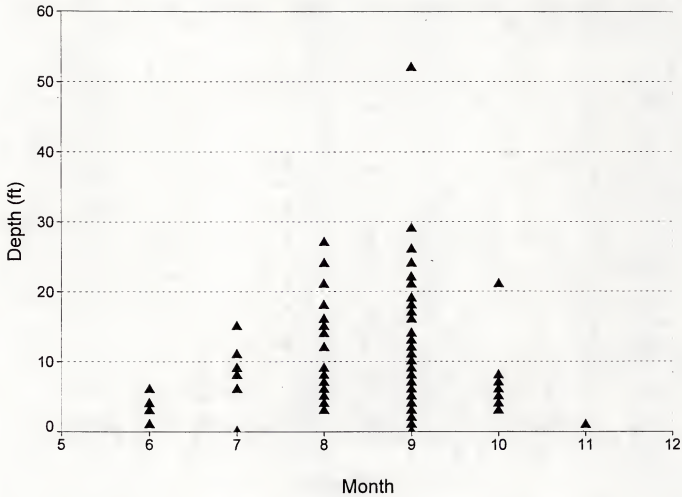


Figure 3. Catches of hatchery rainbow trout in vertical gill nets in Hauser Reservoir, 1986-1995. Each triangle represents one fish.

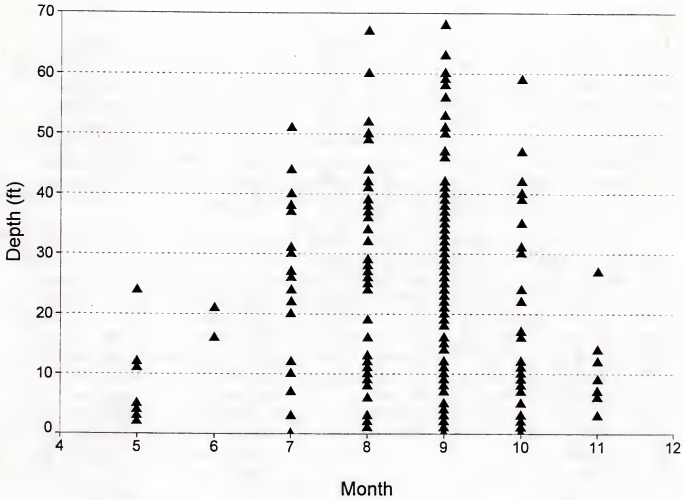


Figure 4. Catches of hatchery rainbow trout in vertical gill nets in Holter Reservoir, 1986-1995. Each triangle represents one fish.

Hauser fish was about 30 feet in August and September. The fish moved to shallower water in all other months, but the small sample size during those months makes it difficult to accurately characterize. Small sample size was also a problem at Canyon Ferry. Net catches were good in July and August, showing that the maximum depth for fish at this time (60-70 feet) was quite similar to the maximum depth for fish in Holter. Sample size was too low to draw conclusions for spring and fall months on Canyon Ferry. However, we assume that the vertical distribution is similar to that of Holter, because the few fish that were captured show general conformity with the Holter distribution. Furthermore, as discussed below, the thermal characteristics in both lakes are similar, so there are no obvious temperature-related effects that might cause the fish distributions to be dissimilar.

The movement of rainbow trout to deeper waters in the summer may be a response to the changing water temperatures. Lere (1991) summarized surface water temperatures at the three reservoirs from 1987 to 1990. During these years, the maximum surface water temperatures were typically reached in early August. The average maximum temperature for the four years ranged from 66.6-72.7° F at Canyon Ferry, 65.1-66.5° at Hauser, and from 66.P-71.2° at Holter. These temperatures are considerably below the critical thermal maximum of 83° reported for rainbow trout which had been acclimated to 50° water (Lee and Rinne 1980). However, the surface temperatures are above the 50-60° range listed as optimum for adult rainbow trout (Piper et al. 1982). Therefore, some of the movement away from surface waters in summer months may be for the purpose of seeking cooler water. Lere (1988) collected detailed temperature profile data on all three reservoirs in 1987. At stations near the lower end of the reservoirs (the same stations as used for vertical gill netting), Lere showed that isothermal or near-isothermal conditions occurred in all reservoirs in April and November. The pattern of thermal stratification was similar between Canyon Ferry and Holter reservoirs. Weak stratification began to develop on both reservoirs in June at depths of 20 to 30 feet. The stratified zone got progressively deeper through the summer until September when it was found at 60-80 feet (Figures 5 and 6). By October, the stratification was hard to recognize. Hauser had a more pronounced temperature stratification than the other reservoirs. A fairly distinct thermocline was detected in June 1987 between 10 and 20 feet, which got deeper and less distinct as the summer progressed (Figure 7). These temperature profiles were used to create plots of the depths at which the upper limit of optimum temperatures are found on the three reservoirs (Figure 8). The penetration of the 60° isotherm began in June for all reservoirs, reaching a maximum depth in August or September, and quickly disappearing in early October. Maximum depth of the 60° isotherm was 85 feet in Canyon Ferry, 48 feet in Holter, and 27 feet in Hauser. A comparison of these isotherms with the seasonal depth distribution of trout (Figures 2-4), suggests that the trout are responding to water temperature. This relationship is not as obvious in all years, however. During the high flow year of 1993, the shape of the 60° isotherm on Canyon Ferry was similar to that of 1987, but on Hauser the isotherm extended to the bottom of the lake for a month.

HYPOTHESIS OF FISH FLUSHING

A major objective of this report is to explain variations in flushing rates at the three dams. We will explore the hypothesis that these variations are due to the quantity of water discharged and

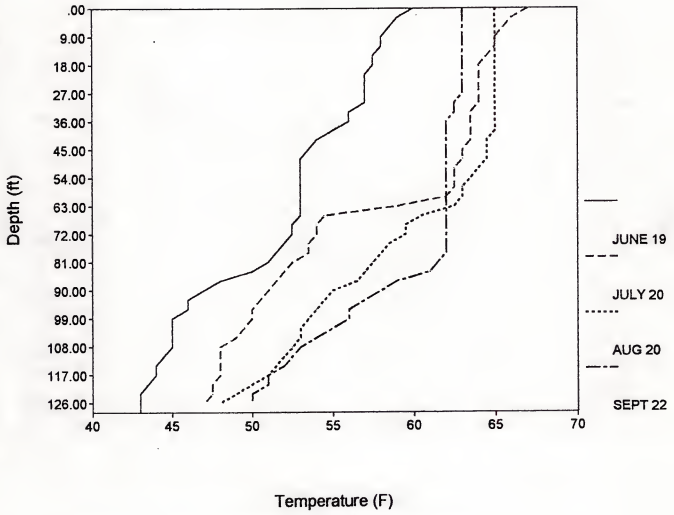


Figure 5. Temperature profiles in Canyon Ferry Reservoir, 1987.

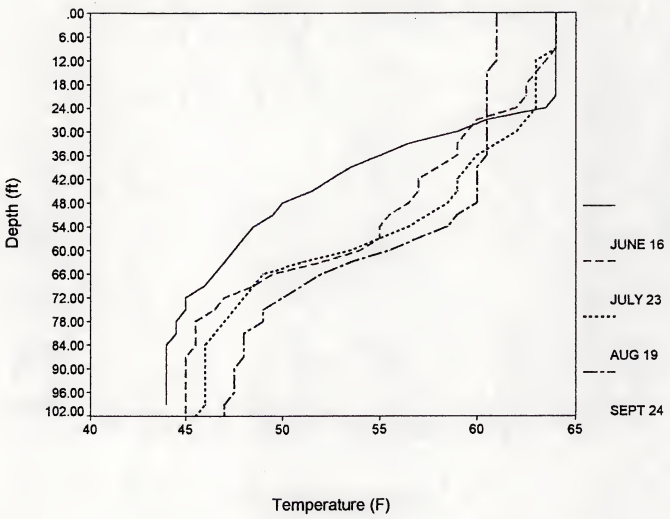


Figure 6. Temperature profiles in Holter Reservoir, 1987.

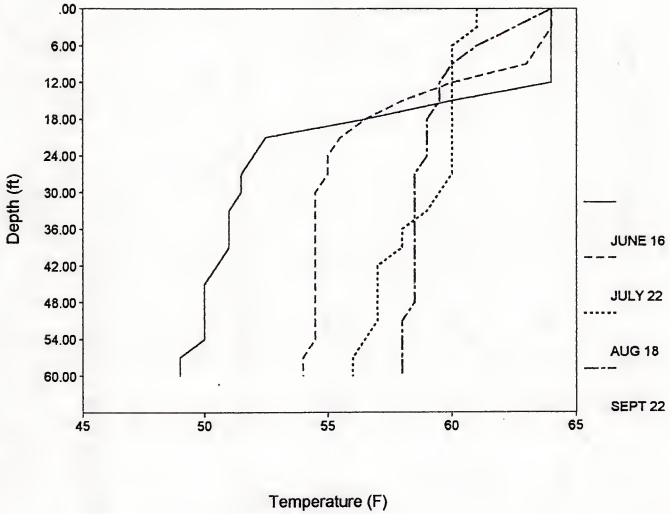


Figure 7. Temperature profiles in Hauser Reservoir, 1987.

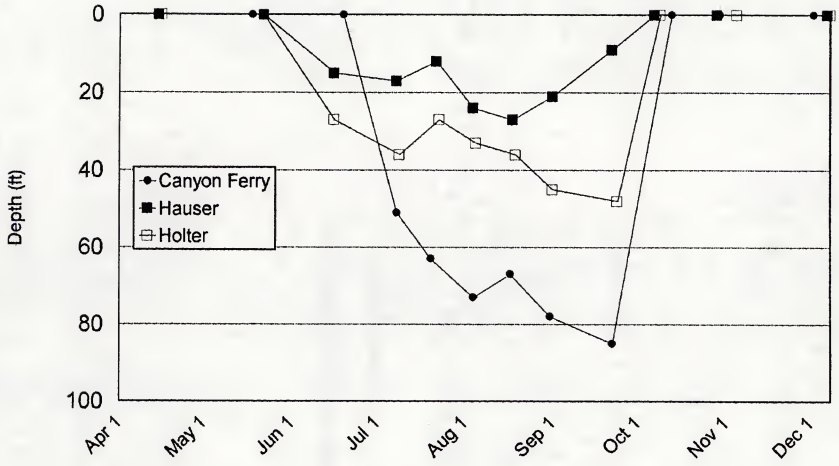


Figure 8. Depths of the 60 degree (F) isotherm at the three reservoirs in 1987.

the proximity of fish to the penstock intakes or spillways. Three other variables that may explain differences in flushing rates, but for which we have insufficient data to evaluate, are: strain of rainbow trout, density of fish, and the lakewide distribution of fish as influenced by their behavior, e.g. spawning and feeding activities. Other studies have shown that many of these variables are responsible for entrainment of kokanee. Skaar et al.(1996) explained 78% of the variance in entrainment rates of kokanee at Libby Dam by using a combination of variables that included dam discharge, areal and volumetric density of fish in the forebay, and depth of water withdrawal. At Banks Lake, Washington, Stober et al. (1979) sampled entrainment of kokanee on a weekly basis and found it to be quite erratic. The authors postulated that this variability was partially due to the volume of irrigation water withdrawn, the effects of maturation, and the feeding movements of the fish in the portion of the lake near the withdrawal structure. Maiolie and Elam (1996) reported on efforts to reduce kokanee entrainment at Dworshak Dam, Idaho. After characterizing seasonal patterns of depth distribution of kokanee in the forebay, they manipulated withdrawal depth and patterns of discharge in order to reduce entrainment. While they did not measure entrainment directly, they saw changes in the kokanee population that they felt were reflective of the changes to dam operations.

We hypothesized that flushing rates of rainbow trout are influenced by the unique operating conditions at each dam and should differ in the following ways:

1) At Canyon Ferry, the potential for flushing will be influenced greatly by annual changes in reservoir levels. Fish will be prone to entrainment through the penstocks only when they are at the depth of the penstocks. Since the penstocks are 84 feet below full pool elevation, the only time trout should be entrained is during the July-September period when they are occupying 60 to 70-ft deep water and the reservoir is at least 14 feet below full pool. Under the operating conditions described previously for the three flow scenarios, it was only the dry year (1992) that had a juxtaposition of these two conditions: the reservoir was drawn down 16 feet in September and the penstocks were at a depth of 68 feet. In most years however, there should be little likelihood of entrainment through the penstocks. Most fish losses will probably be over the spillways, which are operated during high flow periods from May to August. The reservoir level is not stable during these months, and the spillway depth can be anywhere from 15-31 feet. The rainbows occupy these depths throughout the May-August period (see Figure 1), and so losses over the spillway seem likely to occur at any time. However, during May and June, the trout occupy only the shallow waters and are therefore more densely spaced than during summer months; theoretically this should lead to greater rates of flushing (fish per unit volume of water).

2) At Hauser Dam, flushing should occur whenever the spillways are operated, because the spill gates extend from the surface down to 14 feet. When spilling does not occur, entrainment through the turbines probably occurs at least during August and September because net catches show trout using the depth of penstock intakes during this time. Turbine entrainment seems less likely during spring and fall, because almost all hatchery fish were found in water shallower than 16 feet during these months.

3) Holter Dam is much like Hauser, in that fish are probably flushed over the dam whenever spilling occurs, because the spill gates draw water from a depth of 6-16 feet--a depth occupied by trout during all months sampled. Hatchery fish occupy the depth of the penstock intakes (16-30 feet) during the period from July through October and so are presumed to be entrained through the turbines during this time. The fish may be less prone to be entrained in May and November because many of them are found in water shallower than the penstock intakes.

RESULTS AND DISCUSSION

Fish Stocking in the Three Reservoirs

Almost all of the rainbow trout stocked into Hauser and Holter reservoirs during the 1986-1995 period have been of the Arlee strain. The only exception to this was 32,000 McConaughy strain fish stocked into Holter in 1986. The Arlees have all been young-of-the-year (length 4-6 inches) and have been planted in June or July (Table 1). Rainbow trout stocked into Canyon Ferry during this period have been a combination of Arlee, Eagle Lake, DeSmet and McConaughy strains (Table 2). Fish have been stocked as either young-of-the-year or yearlings, at sizes ranging from 3.0-8.9 inches, and from April through September.

Overview of the Datasets and General Trends in Fish Flushing

The data presented here were collected at the three reservoirs from 1986 to 1995, and consist of results from creel surveys, vertical and horizontal gill netting, and tailrace electrofishing. Not all of these sampling techniques were used every year or at the same time each year, and are therefore of varying degrees of usefulness in comparing flushing rates from one year to another or one season to another. Much of the data have been previously reported by Lere (1987, 1988, 1990, 1991 and 1992), Skaar (1994) and Skaar and Humphrey (1995, 1996).

The movement of Canyon Ferry fish into Hauser Reservoir during these years has been documented by gill netting and creel surveys (Tables 3 and 4) as well as by electrofishing (Table 5). Looking at all the data collectively, there were only two years with clearly elevated levels of flushing. In 1986, this was shown by the tailrace and Hauser summer creel surveys as well as the tailrace electrofishing, while in 1995 the Hauser summer creel and all forms of gillnetting had high rates. The high rates in the spring 1995 gill nets were quite unusual, and were probably the result of high numbers of spawners being flushed through the dam. In April and May, large congregations of spawning rainbow trout were seen at the north end of the reservoir and well as near the dam. The discharge through the turbines was relatively constant through the month of May (5,600-6,100 cfs), but spilling from the dam began on the 12th and reached 6,000 cfs by the 18th. Many of these fish were apparently flushed through or over the dam, and caught in the gill nets which were fished from May 15-18. Indications of fish flushing are more ambiguous in the years 1989, 1993 and 1994. In

Table 1. Summary of Arlee Rainbow Trout Stocked into Hauser and Holter Reservoirs, 1985-1995.

	Hauser Reservoir			Holter Reservoir		
Year	Length Range (in)	Number	Date Stocked	Length Range(in)	Number	Date Stocked
1985	4.0-5.0	232,468	5/28-7/17	5.0	310,631	7/8-10
1986	5-6	212,595	7/7-16	5.0	325,089	7/14-30
1987	4.4-4.7	212,840	6/8-18	4.4-4.9	323,002	7/6-8
1988	4.7-5.2	211,780	7/7-20	4.6-4.8	322,887	6/20-7/5
1989	4.3	195,584	6/22-27	4.7-5.0	366,785[1]	7/5-11
1990	4.5	153,962	6/20-26	4.9-5.2	347,257	7/9-25
1991	4.5-4.9	138,058	7/11-23	4.7-5.0	420,067	7/8-23
1992	4.6-4.8	126,354	6/22-24	4.5-5.0	382,753	6/29-7/21
1993	4.9-5.2	118,588	6/20-23	4.3-5.2	360,977	7/12-30
1994	4.8-5.4	105,145	6/21-28	4.6-5.1	290,534	7/7-21
1995	4.9	106,674	7/10-13	5.1-5.7	317,482	7/17-24

[1]This includes 29,070 fish which were planted August 18-22 at a length of 7.2-7.8 inches.

Table 2. Summary of the number of rainbow trout of different strains stocked into Canyon Ferry Reservoir, 1984-1995.

Year	Strain	Number Stocked	Date of Stocking	Length range (in)
1984	DeSmet	702,836	8/27 - 10/30	3.0 - 5.0
1985	Arlee	434,237	5/21 - 8/8	4.0 - 5.0
	DeSmet	257,729	6/6 - 9/12	3.0 - 5.0
	TOTAL	**691,966**		
1986	Arlee	985,449	5/12 - 6/24	4.0 - 6.0
	DeSmet	62,100	5/13 - 5/20	7.0
	TOTAL	**1,047,549**		
1987	Arlee	724,686	5/4 - 6/18	4.4 - 6.9
	Eagle Lake	251,303	7/22 - 8/2	3.8 - 4.4
	TOTAL	**975,989**		
1988	Arlee	766,045	4/28 - 5/24	4.4 - 5.1
	DeSmet	135,513	8/29	3.0
	Eagle Lake	156,552	7/26 - 9/14	4.5 - 4.6
	TOTAL	**1,058,110**		
1989	Arlee	852,158	5/3 - 5/31	4.1 - 5.6
	Arlee	57,746	10/4 - 10/11	6.4 - 7.0
	Eagle Lake	125,048	9/12	4.0
	TOTAL	**1,034,952**		
1990	DeSmet	196,431	4/9 - 5/29	6.2 - 7.0
	Eagle Lake	124,665	6/7 - 6/21	4.5 - 5.2
	Eagle Lake	249,158	9/18 - 9/25	4.0
	TOTAL	**570,254**		
1991	DeSmet	442,234	4/15 - 5/15	4.4 - 7.4
1992	DeSmet	609,017	4/15 - 5/18	4.4 - 5.6
	Eagle Lake	470,344	5/18 - 7/28	3.7 - 4.6
	Eagle Lake	379,946	6/16	6.7
	TOTAL	**1,459,307**		
1993	DeSmet	176,400	4/20 - 5/18	5.4 - 6.9
	DeSmet	737,041	6/10 - 6/28	2.8 - 3.6

Table 2. Continued

Year	Strain	Number Stocked	Date of Stocking	Length range (in)
	Eagle Lake	905,420	5/18 - 7/2	3.0 - 3.6
	McConaughy	27,861	6/16	3.6
	TOTAL	**1,846,722**		
1994	DeSmet	723,710	5/30 - 6/10	2.5 - 2.9
	DeSmet	168,053	5/2 - 5/26	6.4 - 6.5
	Eagle Lake	608,506	5/16 - 6/1	2.5 - 3.1
	TOTAL	**1,500,269**		
1995	DeSmet	262,123	5/15 - 5/31	5.7 - 6.5
	Eagle Lake	94,871	5/16 - 5/18	6.8 - 8.9
	TOTAL	**356,994**		

Table 3. Summary of the number of hatchery rainbow trout from Canyon Ferry captured in gill nets and observed in creel surveys on Hauser Reservoir, 1986-1995.

		Angler Catch and Catch Rates						Gill Nets					
		Canyon Ferry Tailrace Creel		Hauser Summer Creel		Hauser Winter Creel		Horizontal					
								Spring		Fall		Vertical	
Year	Strain	No.	No./hr	No.	No./hr	No.	No./hr	No.	No./net	No.	No./net	No.	No./net
1986	Arlee	18	0.024	18	0.006	--	--	0	0.00	0	0.00	0	0.00
	DeSmet	2	0.003	10	0.003	--	--	0	0.00	2	0.13	1	0.08
	Unknown	6	0.008	11	0.003	--	--	0	0.00	0	0.00	0	0.00
	TOTAL	**26**	**0.034**	**39**	**0.012**	**--**	**--**	**0**	**0.00**	**2**	**0.13**	**1**	**0.08**
1987	Arlee	1	0.001	4	0.0009	--	--	0	0.00	0	0.00	0	0.00
	Eagle Lake	0	0.000	0	0.000	--	--	0	0.00	1	0.06	0	0.00
	DeSmet	0	0.000	0	0.000	--	--	0	0.00	1	0.06	0	0.00
	Unknown	0	0.000	1	0.0002	--	--	0	0.00	0	0.00	0	0.00
	TOTAL	**1**	**0.001**	**5**	**0.0012**	**--**	**--**	**0**	**0.00**	**2**	**0.12**	**0**	**0.00**
1988	Arlee	1	0.006	0	0.00	0	0.00	0	0.00	2	0.12	0	0.00
1989	Eagle Lake	--	--	1	0.0004	0	0.00	0	0.00	2	0.12	0	0.00
1990	Arlee	--	--	2	0.0003	0	0.00	0	0.00	0	0.00	0	0.00
	Eagle Lake	--	--	2	0.0003	0	0.00	0	0.00	0	0.00	0	0.00
	TOTAL	**--**	**--**	**4**	**0.0006**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**0.00**

Table 3, continued.

Year	Strain	Angler Catch and Catch Rates						Gill Nets					
		Canyon Ferry Tailrace Creel		Hauser Summer Creel		Hauser Winter Creel		Horizontal					
								Spring		Fall		Vertical	
		No.	No./hr	No.	No./hr	No.	No./hr	No.	No./net	No.	No./net	No.	No./net
1991	Arlee	--	--	1	0.0001	0	0.00	0	0.00	0	0.00	0	0.00
	DeSmet	--	--	0	0.00	0	0.00	0	0.00	1	0.06	0	0.00
	Eagle Lake	--	--	0	0.00	0	0.00	1	0.06	1	0.06	0	0.00
	TOTAL	**--**	**--**	**1**	**0.0001**	**0**	**0.00**	**1**	**0.06**	**2**	**0.12**	**0**	**0.00**
1992	DeSmet	--	--	0	0.00	1	0.0009	0	0.00	0	0.00	0	0.00
1993	DeSmet	--	--	0	0.00	0	0.00	1	0.06	2	0.11	0	0.00
	Eagle Lake	--	--	4	0.002	0	0.00	0	0.00	5	0.28	1	0.04
	TOTAL	**--**	**--**	**4**	**0.002**	**0**	**0.00**	**1**	**0.06**	**7**	**0.39**	**1**	**0.04**
1994	DeSmet	--	--	0	0.00	0	0.00	3	0.18	0	0.00	1	0.04
	Eagle Lake	--	--	2	0.0006	0	0.00	2	0.12	3	0.18	1	0.04
	TOTAL	**--**	**--**	**2**	**0.0006**	**0**	**0.00**	**5**	**0.30**	**3**	**0.18**	**2**	**0.07**
1995	DeSmet	--	--	14	0.006	2	0.003	21	1.40	4	0.22	1	0.02
	Eagle Lake	--	--	12	0.005	0	0.000	11	0.73	1	0.06	2	0.05
	TOTAL	**--**	**--**	**26**	**0.012**	**2**	**0.003**	**33**	**2.13**	**5**	**0.28**	**3**	**0.07**

Table 4. Beginning and ending dates for creel surveys on Hauser and Holter reservoirs, 1986-1995.

Year	Hauser Reservoir		Holter Reservoir		Canyon Ferry Tailrace	Holter Tailrace[1]
	Summer	Winter	Summer	Winter		
1986	4/19-10/31	--	4/25-10/9	--	9/23-11/25	--
1987	4/14-11/19	--	4/14-10/12	--	8/2-11/19	4/5-9/20
1988	4/25-11/23	--	5/4-11/12	--	9/17-11/23	--
1989	5/22-11/12	1/11-3/24	5/27-11/11	1/11-3/24	--	--
1990	4/16-11/17	12/29-2/26	3/16-11/13	1/20-3/2	--	--
1991	4/15-11/5	12/27-3/14	4/15-10/26	12/31-3/7	--	--
1992	5/18-11/8	1/4 - 3/5	5/19-11/8	1/21-2/15	--	--
1993	4/28-10/29	12/17-3/27	4/28-10/29	1/8-3/21	--	5/16-9/27
1994	4/22-9/25	1/18-3/6	4/22-9/24	1/24-2/27	--	--
1995	4/1-10/28	12/17-2/25	4/1-10/28	1/8-2/18	--	5/21-10/21

[1]Holter tailrace creel surveys were always part of a larger Missouri River creel. The dates indicated here are those during which fish were inspected for spray marks.

Table 5. Selected data summary of the numbers, origin and strains of rainbow trout captured in the tailwaters of Canyon Ferry, Hauser and Holter Dams during electrofishing surveys, 1986-1993.

Year	Date(s)	Strain/ Lake of origin	Age or length	Number caught	Percent of total
		Canyon Ferry Dam tailwaters			
1986	8/5,6	Arlee/Hauser	0+	107	41.6
	9/22	Arlee/Canyon Ferry	0+	47	18.3
	10/27	DeSmet/Canyon Ferry	1+	11	4.3
		Unknown or wild	0+	60	23.3
		Unknown or wild	1+ & older	32	12.5
1987	9/2,17	Arlee/Hauser	0+	211	87.6
		Arlee/Hauser	1+ & older	1	0.4
		Arlee/Canyon Ferry	0+	1	0.4
		E.Lake/Canyon Ferry	0+	5	2.1
		Unknown or wild	0+	19	7.9
		Unknown or wild	1+ & older	4	1.7
1988	9/19	Arlee/Hauser	0+	152	91.6
		Arlee/Hauser	1+ & older	2	1.2
		E.Lake/Canyon Ferry	0+	1	0.6
		Unknown or wild	0+	8	4.8
		Unknown or wild	1+ & older	3	1.8

Table 5, continued.

Year	Date(s)	Strain/ Lake of origin	Age or length	Number caught	Percent of total
		Canyon Ferry Dam tailwaters			
1989	11/28	Arlee/Hauser	0+	62	59.0
		Arlee/Hauser	1+ & older	9	8.6
		Arlee/Canyon Ferry	0+	11	10.5
		Eagle Lake/Canyon Ferry	0+	13	12.4
		Eagle Lake/Canyon Ferry	1+ & older	1	1.0
		Unknown or wild	0+	7	6.7
		Unknown or wild	1+ & older	2	1.9
1991	6/27	Arlee/Hauser	1+ & older	1	14.3
		DeSmet/Canyon Ferry	0+	1	14.3
		Eagle Lake/Canyon Ferry	1+ & older	3	42.9
		Unknown or wild	1+ & older	2	28.6
1993	7/19	DeSmet/Canyon Ferry	0+	5	38.5
		Eagle Lake/Canyon Ferry	0+	4	30.8
		Eagle Lake/Canyon Ferry	1+ & older	3	23.1
		Unknown or wild	1+ & older	1	7.7

Table 5, continued.

Year	Date(s)	Strain/ Lake of origin	Age or length	Number caught	Percent of total
		Hauser Dam Tailwaters (Hauser Section)			
1986	11/3,17	Arlee/Hauser	8-12 in	121	16.0
		All others (hatchery from Holter, wild, unknown)	8-12 in	637	84.0
		(Modified Peterson population estimate of Hauser fish was 819)			
1987	10/26,27	Arlee/Hauser	8-12 in (age 0+)	3	0.2
	11/2	All others (hatchery from Holter, wild, unknown)	8-12 in	1,841	99.8
1989	10/30	Arlee/Hauser	8-12 in (age 0+)	125	7.6
	11/7,15	All others (hatchery from Holter, wild, unknown)	8-12 in	1,529	92.4
1990	11/6,8	Arlee/Hauser	8-12 in (age 0+)	23	1.3
	11/19	All others (hatchery from Holter, wild, unknown)	8-12 in	1,775	98.7
1993	7/20	Arlee/Hauser	Age 1+ & older	2	4.4
		All others (hatchery from Holter, wild, unknown)	All	43	95.6

Table 5, continued.

Year	Date(s)	Strain/ Lake of origin	Age or length	Number caught	Percent of total
		Holter Dam Tailwaters (Holter Section)			
1986	9/17,18	Arlee/Holter	6.5-11 in (age 0+)	329	47.8
	10/2,6	Wild or unknown	6.5-11 in	359	52.2
		(Modified Peterson population estimate of Holter fish was 1711.)			
1987	9/15,16	Arlee/Holter	8-11.5 in (age 0+)	35	9.0
	9/30,10/1	Wild or unknown	8-11.5 in	355	91.0
1988	9/20	Arlee/Holter	6-11.5 in (age 0+)	3	6.1
		Wild or unknown	6-11.5 in (age 0+)	46	93.9
1991	6/19	Arlee/Holter	12-16 in (1+ & older)	4	9.3
		Wild or unknown	12-16 in	39	90.7
1993	7/21	Arlee/Holter	4.5-7 in (age 0+)	4	33.3
		Wild or unknown	4.5-7 in	8	66.7
1993	11/2,3	Arlee/Holter	7-13 in (age 0+)	225	30.7
	11/15,16	Wild or unknown	7-13 in	507	69.3
		(Modified Peterson population estimate of Holter fish was 1280.)			

each of these years, one sampling method showed elevated rates of flushing, but three or more other methods showed no elevated levels. In the 1989 tailrace electrofishing surveys, 23.9% of the rainbow trout were from Canyon Ferry. This is an elevated level, comparable to the 1986 level of 22.6% and much higher than the surveys in 1987 and 1988 which showed that only 2.9 and 0.6% of the rainbow trout, respectively, were from Canyon Ferry. Apparent elevated flushing levels in 1993 and 1994 were suggested by catches in fall and spring gill nets, respectively. In both years, the gill nets had only modestly higher numbers of flushed fish than were captured in all other years.

Gill netting, creel surveys and electrofishing were also used to document the movement of Canyon Ferry and Hauser rainbows into Holter Reservoir. As expected, many more fish were captured that had drifted from Hauser Reservoir than from Canyon Ferry. No Canyon Ferry fish were caught during five electrofishing surveys in the Hauser tailwaters, although 274 Hauser fish were captured (Table 5). Similarly, only seven Canyon Ferry fish were caught in ten years of gill net and creel surveys on Holter, compared to 22 Hauser fish caught (Table 6). Hauser fish seemed to move into Holter in relatively large numbers in 1986 (based on tailrace electrofishing, summer creel and spring gill netting) and in 1989 (based on electrofishing). Movement of fish into Holter seemed to be lower in all other years.

The movement of hatchery rainbows downstream into the Missouri River below Holter Dam was determined by tailrace creel surveys and electrofishing. The electrofishing results indicate that flushing was high in 1986 and 1993, where 47.8% and 30.7% of the small rainbow trout (6-13 inches) were young-of-the-year Arlees from Holter Reservoir (Table 5). The percentage of Arlees in 1987, 1988 and 1991 was much lower. Only three creel surveys have been conducted between Holter Dam and Wolf Creek Bridge where the creel clerks were inspecting fish for spray marks. In 1987, 52% of 83 rainbow trout that were inspected between April and August were Holter Arlees (Table 7). In 1993, 322 rainbows were inspected from May through September and 39.8% were Holter Arlees (Table 8). In 1995, only 20 rainbows were inspected between May 21 and October 21, and 6 of the fish (30% of total) were Holter Arlees (file data).

All of the data from the three reservoirs were summarized in one table (Table 9), where a +, - or blank was assigned to each collection method as a relative measure of the degree of flushing that occurred. Comparisons between years and between dams was confounded by the relative lack of data at Holter compared to the other dams, and by the fact that not all sample methods were used every year. However, we can use the table to make some generalizations about trends in flushing, but it is of limited use in understanding the mechanisms of fish flushing because it ignores seasonal aspects of dam operation and fish distribution. There were three years that distinguished themselves as having elevated levels of flushing. Flushing at all three dams was elevated in 1986, two dams (Canyon Ferry and Hauser) were elevated in 1993, and only Canyon Ferry was elevated in 1995 (but with strong indications from all four sampling methods). At the other end of the scale, all three dams showed low levels of flushing in 1988, while both Canyon Ferry and Hauser showed low levels in 1990 and 1992. This is generally consistent with the hypothesis that high levels of flushing will follow high levels of discharge and spill. The years of elevated flushing (1986, 1993 and 1995) were

Table 6. Summary of the number of hatchery rainbows from Canyon Ferry and Hauser reservoirs captured in gillnets and observed in creel surveys on Holter Reservoir, 1986-1995.

			Angler Catch and Catch Rates				Gill Nets					
			Summer Creel		Winter Creel		Horizontal					
							Spring		Fall		Vertical	
Year	Strain	Reservoir of Origin	No.	No./hr	No.	No./hr	No.	No./net	No.	No./net	No.	No./net
1986	Arlee	Hauser	5	0.002	--	--	4	0.67	1	0.07	1	0.04
1987	Arlee	Hauser	1	0.0003	--	--	2	0.15	1	0.07	0	0.00
1988	Arlee	Hauser	2	0.0008	0	0.00	0	0.00	0	0.00	0	0.00
1989	Arlee	Hauser	0	0.000	0	0.00	0	0.00	1	0.07	0	0.00
	Eagle Lake	Canyon Ferry	2	0.001	0	0.00	0	0.00	1	0.07	0	0.00
	TOTAL		**2**	0.001	0	0.00	0	0.00	**2**	0.14	0	0.00
1990	Arlee	Hauser	1	0.0004	0	0.00	0	0.00	0	0.00	0	0.00
	DeSmet	Canyon Ferry	0	0.000	1	0.001	0	0.00	0	0.00	0	0.00
	TOTAL		**1**	0.0004	**1**	0.001	0	0.00	0	0.00	0	0.00
1991	DeSmet	Canyon Ferry	0	0.00	1	0.0009	0	0.00	0	0.00	0	0.00
1993	Arlee	Hauser	2	0.0005	0	0.00	0	0.00	0	0.00	0	0.00
	Eagle Lake	Canyon Ferry	1	0.0003	0	0.00	0	0.00	0	0.00	0	0.00
	TOTAL		**3**	0.0008	0	0.00	0	0.00	0	0.00	0	0.00
1994	Arlee	Hauser	1	0.0003	0	0.00	0	0.00	0	0.00	0	0.00
1995	DeSmet	Canyon Ferry	1	0.0008	0	0.00	0	0.00	0	0.00	1	0.04
	Eagle Lake	Canyon Ferry	1	0.0008	0	0.00	0	0.00	0	0.00	0	0.00
	TOTAL		**2**	0.0016	0	0.00	0	0.00	0	0.00	**1**	0.04

Table 7. Summary of the 1987 Missouri River creel, showing the number of unmarked and spray-marked rainbow trout inspected by the creel clerk in the section from Holter Dam to Wolf Creek Bridge. All spray-marked fish were from the 1986 Holter Reservoir plant.

Month	C	SM	SM/C[a]
April	12	3	0.25
May	13	5	0.38
June	50	35	0.70
July	4	0	0.00
August	4	0	0.00
TOTAL	**83**	**43**	**0.52**

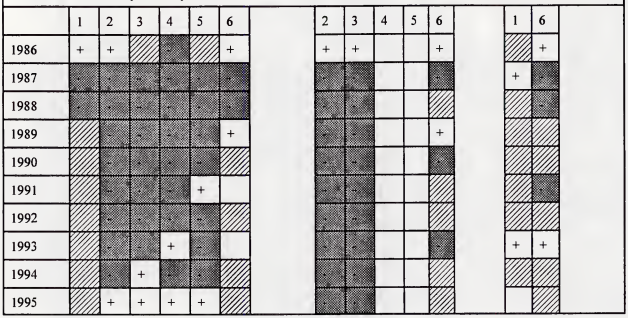
[a]C=number of fish inspected by creel clerk; SM=number of inspected fish that were spray-marked.

Table 8. Summary of the 1993 Missouri River creel survey showing the number of unmarked and spray-marked rainbow trout inspected by the creel clerk.

	Section 1 (Holter Dam to Wolf Creek Bridge)			Section 2 (Wolf Creek Bridge to Craig Bridge)			Section 3 (Craig Bridge to Dearborn Inn)			Section 4 (Dearborn Inn to Mountain Palace FAS)			Sections 5-8 (Mtn. Palace FAS to Smith River		
Month	C	SM	SM/C[a]	C	SM	SM/C[a]	C	SM	SM/C[a]	C	SM	SM/C[a]	C	SM	SM/C[a]
May	32	3(A)[b]	0.094	[illegible]	0	--	0	0	--	0	0	--	0	0	--
	3	(EL)	0.094												
June	38	10(A)	0.26	12	0	0.0	2	0	0.0	2	1(EL)	0.50	3	0	0.0
July	93	1[illegible](A)	0.505	25	1(A)	0.04	11	0	0.0	6	0	0.0	3	0	0.0
August	85	36(A)	0.424	2[illegible]	0	0.0	11	0	0.0	7	0	0.0	1[illegible]	0	0.0
Sept	74	31(A)	0.419	[illegible]	0	0.0	15	0	0.0	5	0	0.0	18	0	0.0
		1(EL)	0.014												
TOTAL	322	128(A)	0.398	72	1(A)	0.014	39	0	0.0	20	1(EL)	0.05	40	0	0.0
		4(EL)	0.012												

[a]C= Number of fish inspected by creel clerk; SM= Number of inspected fish that were spray marked.
[b]A= Arlee strain, EL=Eagle Lake strain.

Table 9. Relative rates of rainbow trout flushing through the three mid-Missouri River dams, 1986-1995. Sample methods are: 1=tailrace creel; 2=reservoir creel; 3= spring horizontal gill nets; 4=fall horizontal gill nets; 5=vertical gill nets; 6=tailrace electrofishing. + symbol means relatively high flushing rates; - symbol means relatively low flushing rates; blank box means that data were insufficient to determine relative rates of flushing or no tendency was indicated; diagonal lines means no data for that year.



the top three for discharge and spill at all dams for the 1986-1995 period (Table 10), while the years of depressed flushing (1988,1990 and 1992) were among the lowest for discharge and spill.

As another measure of the effect of discharge and spill on fish flushing, we examined catch rates of hatchery trout in fall horizontal gill nets in Hauser and Holter reservoirs. If there is such an effect, then higher discharges should lead to a lower retention of hatchery fish in the reservoirs and to lower catch rates in the nets. In Hauser, we found that the number of fish captured in their first fall after planting ranged from a low of five in 1995 to a high of 158 in 1988 (Table 11). Variability was much less in Holter, where numbers ranged from a low of 16 in 1993 to a high of 60 in 1987. These numbers were compared to the quantity of water discharged and spilled between the time of stocking and the time of fall netting (Table 12). Negative correlations were found between all three measures of the number of hatchery fish and all three measures of dam discharge for both reservoirs (Table 13). Correlations for Hauser were stronger than for Holter, although only two Hauser correlations were significant: total turbine discharge vs. the number of fish in the first fall, and total turbine discharge vs. the number of fish in the first and second falls combined (Figure 9). Correlations between the number of fish and quantity of spill were not significant, but were strong and negative. Spill quantity and turbine quantity were found to covary, however ($r = 0.7798$ for the first fall after stocking). In order to remove the effect of one of these variables on the other, partial correlations were performed on number of fish and turbine discharge (in the first fall after stocking) with the effect of spill removed. The correlation was no longer significant ($r = -0.4088$, $P = 0.275$). Similarly, when a partial correlation was conducted on the number of fish and spill quantity with the effect of turbine discharge removed, the correlation was weaker ($r = -0.1178$, $P = 0.763$). This suggests that both spill and turbine discharge contribute to fish flushing.

Electrofishing efforts in the Canyon Ferry tailrace provided additional evidence that flushing rates are related to quantity of discharge. In the tailrace electrofishing for the years 1986 through 1989, the Canyon Ferry hatchery fish comprised 22.6%, 2.5%, 0.6%, and 22.9% of all rainbow trout captured during the four years, respectively. These percentages are positively related to the quantity of discharge, as the amount of water released through the dam between the time of stocking and electrofishing was 78.1, 34.2, 38.4, and 57.3 billion ft^3, respectively, for the four years (Figure 10).

Age-Specific Differences in Flushing of Arlee Rainbow Trout

The tailrace electrofishing surveys conducted during the fall were used to assess age-specific differences in flushing of Arlee rainbow trout. The sample size of age 0+ and age 1+ fish was adequate to make such comparisons in each of two different years for both the Hauser and Holter Dam tailraces. Length-frequency analysis was used to assign fish to the two age classes. In the Hauser tailrace in November 1989, the number and percentage of age 0+/age 1+ hatchery fish was 125/4 (96.9%/3.1%). In November 1990, the age 0+/age 1+ numbers were 23/2 (92%/8%). At Holter, age 0+/age 1+ numbers from electrofishing in September 1987 were 35/8 (81.4%/18.6%). In November 1993, age 0+/age 1+ numbers were 225/9 (96.2%/3.8%). The percentage of age 0+ fish was consistently high in all four of these comparisons, and may simply be a reflection of the large

Table 10. Discharge and spill (ft^3) from Canyon Ferry, Hauser and Holter dams for the calendar year, 1986-1995

Year	Turbine	Spillway	River Outlet	Helena Valley Turbine	Total
			Canyon Ferry Dam		
1986	1.53E+11[a]	5.23E+09	6.24E+08	4.05E+09	1.63E+11
1987	1.07E+11	0.00E+00	0.00E+00	4.52E+09	1.11E+11
1988	9.67E+10	1.04E+07	6.91E+06	4.81E+09	1.01E+11
1989	1.08E+11	2.59E+04	0.00E+00	4.30E+09	1.12E+11
1990	1.06E+11	0.00E+00	0.00E+00	4.19E+09	1.10E+11
1991	1.22E+11	4.16E+09	1.91E+09	4.44E+09	1.32E+11
1992	9.47E+10	0.00E+00	0.00E+00	5.37E+09	1.00E+11
1993	1.51E+11	2.03E+10	6.04E+09	3.26E+09	1.80E+11
1994	1.09E+11	0.00E+00	8.64E+04	4.89E+09	1.14E+11
1995	1.52E+11	3.22E+10	9.82E+09	3.92E+09	1.98E+11
			Hauser Dam		
1986	1.24E+11	4.26E+10	--	--	1.67E+11
1987	1.04E+11	1.10E+10	--	--	1.15E+11
1988	1.05E+11	7.03E+08	--	--	1.05E+11
1989	1.10E+11	5.47E+09	--	--	1.15E+11
1990	1.08E+11	6.11E+09	--	--	1.14E+11
1991	1.17E+11	1.94E+10	--	--	1.36E+11
1992	1.02E+11	2.46E+09	--	--	1.04E+11
1993	1.25E+11	5.70E+10	--	--	1.82E+11
1994	1.11E+11	7.41E+09	--	--	1.18E+11
1995	1.28E+11	7.31E+10	--	--	2.01E+11
			Holter Dam		
1986	1.63E+11	6.10E+09	--	--	1.69E+11
1987	1.17E+11	0.00E+00	--	--	1.17E+11
1988	1.07E+11	0.00E+00	--	--	1.07E+11
1989	1.18E+11	1.68E+08	--	--	1.18E+11
1990	1.19E+11	0.00E+00	--	--	1.19E+11
1991	1.36E+11	4.73E+09	--	--	1.40E+11
1992	1.06E+11	9.76E+07	--	--	1.06E+11
1993	1.78E+11	2.04E+10	--	--	1.99E+11
1994	1.28E+11	0.00E+00	--	--	1.28E+11
1995	1.65E+11	4.37E+10	--	--	2.09E+11

[a]E+11 refers to the exponential power, e.g. 1.53E+11 = 1.53 x 10^{11} cubic feet of water.

Table 11. Number of hatchery rainbow trout caught in fall floating gill nets on Hauser and Holter reservoirs in the first and second fall after stocking. Numbers include only fish captured from the same lake in which they were stocked. Number of captured fish also expressed as a percent of the total fish stocked. The number of nets was the same for all years.

	Hauser Reservoir						Holter Reservoir					
Year Fish Stocked	1st Fall		2nd Fall		Total For Both Years		1st Fall		2nd Fall		Total For Both Years	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1986	62	0.029	10	0.005	72	0.034	47	0.014	36	0.011	83	0.025
1987	56	0.026	16	0.008	72	0.034	60	0.019	4	0.001	64	0.020
1988	158	0.075	6	0.003	164	0.077	21	0.007	4	0.001	25	0.008
1989	59	0.030	13	0.007	72	0.037	36	0.010	4	0.001	40	0.011
1990	50	0.032	4	0.003	54	0.035	24	0.007	4	0.001	28	0.008
1991	26	0.019	14	0.010	40	0.029	18	0.004	0	0.0	18	0.004
1992	32	0.025	13	0.010	45	0.036	37	0.010	0	0.0	37	0.010
1993	8	0.007	0	0.0	8	0.007	16	0.004	0	0.0	16	0.004
1994	19[1]	0.018	2[1]	0.002	21	0.020	20	0.007	3	0.001	23	0.008
1995	5	0.005	--	--	--	--	22	0.007	--	--	--	--

[1]Classification based on the presence of a severely eroded dorsal fin.

Table 12. Dam discharges (ft^3) and spill from the time of stocking until the time of fall netting--in the first and second fall following stocking. T = total discharge through turbines and spillway; S = spillway discharge only.

	1st Fall		2nd Fall		Both Falls	
Year	T	S	T	S	T	S
			Hauser Reservoir			
1986	3.78E+10	4.74E+09	1.24E+11	2.55E+10	1.62E+11	3.02E+10
1987	2.92E+10	3.59E+08	1.10E+11	7.03E+08	1.39E+11	1.06E+09
1988	2.47E+10	0.00E+00	1.15E+11	5.25E+09	1.40E+11	5.25E+09
1989	2.92E+10	5.88E+07	1.12E+11	3.79E+09	1.41E+11	3.85E+09
1990	3.42E+10	1.40E+09	1.34E+11	2.17E+10	1.68E+11	2.31E+10
1991	3.49E+10	2.27E+09	1.08E+11	2.60E+09	1.43E+11	4.87E+09
1992	2.77E+10	1.68E+07	1.64E+11	4.80E+10	1.92E+11	4.80E+10
1993	6.82E+10	3.02E+10	1.34E+11	1.65E+10	2.02E+11	4.67E+10
1994	2.67E+10	4.05E+08	1.90E+11	6.55E+10	2.17E+11	6.59E+10
1995	5.42E+10	2.05E+10	--	--	--	--
			Holter Reservoir			
1986	3.96E+10	0.00E+00	1.26E+11	0.00E+00	1.66E+11	0.00E+00
1987	3.05E+10	0.00E+00	1.12E+11	0.00E+00	1.43E+11	0.00E+00
1988	3.38E+10	0.00E+00	1.15E+11	1.68E+08	1.49E+11	1.68E+08
1989	2.73E+10	0.00E+00	1.18E+11	0.00E+00	1.45E+11	0.00E+00
1990	3.26E+10	0.00E+00	1.40E+11	4.73E+09	1.73E+11	4.73E+09
1991	4.15E+10	0.00E+00	1.08E+11	9.76E+07	1.50E+11	9.76E+07
1992	2.81E+10	9.76E+07	1.80E+11	2.04E+10	2.08E+11	2.05E+10
1993	6.01E+10	5.09E+09	1.45E+11	0.00E+00	2.05E+11	5.09E+09
1994	2.73E+10	0.00E+00	1.91E+11	4.38E+10	2.18E+11	4.38E+10
1995	4.53E+10	4.09E+09	--	--	--	--

Table 13. Correlation coefficients between the number of hatchery fish captured in horizontal gill nets on Hauser and Holter reservoirs and dam discharge. Correlations are from data in Tables 11 and 12.

	N	Total Dam Discharge	Total Spill	Total Turbine
		Hauser Reservoir		
Net catch/ first fall	10	-0.6154	-0.5635	-0.6508[a]
Net catch/ second fall	9	-0.2750	-0.2057	-0.4048
Net catch/ both falls	9	-0.6055	-0.5409	-0.6743[b]
		Holter Reservoir		
Net catch/ first fall	10	-0.4472	-0.4024	-0.4333
Net catch/ second fall	9	-0.1586	-0.1761	-0.1171
Net catch/ both falls	9	-0.3125	-0.2303	-0.2947

[a]Significant at P = 0.042 level
[b]Significant at P = 0.046 level

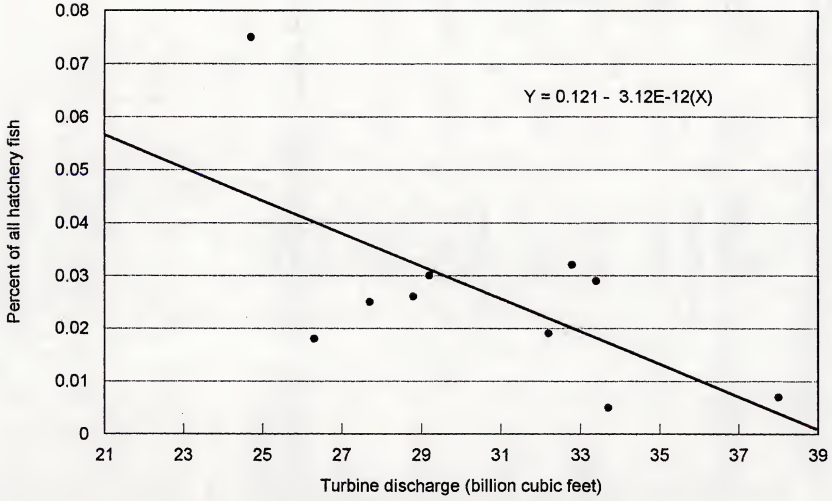


Figure 9. Turbine discharge vs. percent of hatchery fish caught in gill nets during their first fall in Hauser Reservoir, 1986-1995. Data taken from Table 11.

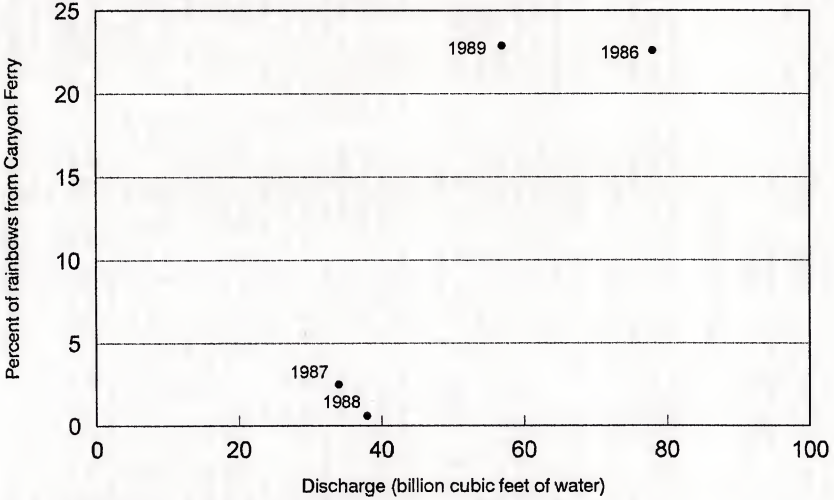


Figure 10. Scatterplot of the percent of rainbow trout captured during Canyon Ferry tailrace electrofishing (1986-1989) that were from Canyon Ferry Reservoir vs. the discharge from the dam between the time of stocking and the time of electrofishing.

number of fish in that age class that are available to be flushed. Gill net catches summarized in Table 11 provide an indication of the relative density of age 0+ and 1+ fish in the reservoirs that were available for flushing. For the years 1986-1994 combined, an average of 84.6 and 88.6% of Arlees were age 0+ in Hauser and Holter Reservoirs. These numbers compare favorably with the percentage of age 0+ fish in the electrofishing surveys, which suggests that these two age classes are being flushed at rates that approximate their density in the reservoir.

Seasonal Trends in Flushing

The seasonality of fish flushing can only be established through some kind of continuous monitoring, and for this study, creel surveys are the primary sample method available for this purpose. Seasonal measurements are useful here primarily because they can help isolate the individual effects that turbine discharge and spill have on flushing rates.

Hill (1973) summarized the results of entrainment studies conducted on Hauser and Holter reservoirs between 1969 and 1972. Rainbow trout were released under a variety of conditions and locations, and their movements were determined by angler creel surveys. In the first experiment, 2,000 seven- to ten- inch albino rainbow trout were released in mid-July 1969 about one mile above Holter dam. The discharge from the dam was running at 13-15,000 cfs at this time. Within three days these fish were being caught in the river below by anglers. These fish were common in the catch for the next month, with the last reported catch being in February 1970. The majority of the albino fish (85%) were caught in the river, while only 15% were caught in the reservoir.

On April 27, 1970, 2,500 seven- to nine-inch rainbow trout were released in Holter Reservoir at the Gates of the Mountains boat ramp. A similar number of fish were released at the Indian trail boat ramp on May 5, 1970. These two lots of fish were distinguished by different colored jaw tags. Of the fish stocked at the Gates, only 4% were returned by anglers by the end of 1972. Ten percent of the tag returns were from the upper end of the reservoir, 45% from the lower end, and 45% from the river below. By comparison, 20% of the tags were returned from the fish stocked at Indian Trail boat ramp. Of these, 2% came from areas of the reservoir upstream of the release site, 45% from the reservoir below the release site, and 53% from the river below. Almost all of the tagged fish caught in the river were from the first mile below the dam. The temporal pattern of tag returns was quite different for fish caught in the reservoir than for those caught in the river (Table 14). About 56% of the tags from reservoir-caught fish were returned in 1970, while 38% were in 1971, and 6% were in 1972. For river-caught fish the drop between successive years was much quicker: 79% of the tags were returned in 1970, 19% in 1971 and 2% in 1972. The temporal pattern of flushing during 1970 showed that the Indian Trail fish began to leave the reservoir within a month of stocking; five tags were returned from the river in May (Table 14). Numbers of returned tags peaked during the month of July (98 tags) and then dropped sharply in August and slowly decreased through the fall to a low of two tags in December. The pattern of tag returns bears a strong resemblance to the pattern of discharge from the dam, which rose sharply when spilling began in early May, peaked in June, and dropped quickly in early July (Figure 11). This suggests that there is a causal relationship between the volume of water spilled and the number of fish flushed through the dam and subsequently caught in the river. However, it should be noted that the high number of tag returns from June-August was,

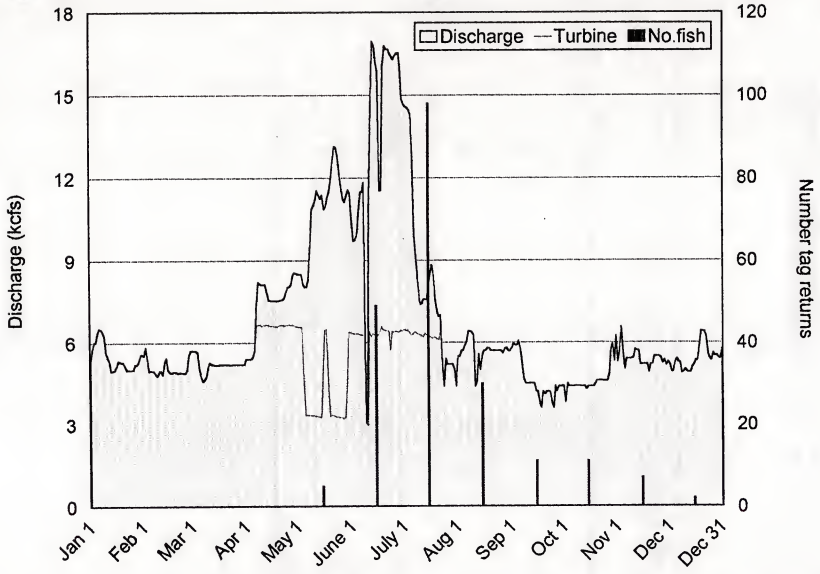


Figure 11. Plot of discharge from Holter Dam during 1970. All water above the dotted line was spilled; everything below the line went through the turbines. Vertical bars indicate monthly totals of the number of jaw tags returned by anglers. Tags were from fish planted in the reservoir and caught in the river.

at least in part, a reflection of a seasonal peak in fishing pressure. While there were no pressure estimates calculated for 1970, the estimates done in 1993 showed that these are the peak months for pressure (see Table 21). Therefore, if the tag numbers had been normalized (i.e. presented as the number of tags per angler hour), then the dominance of the summer months would probably have been somewhat reduced.

Table 14. Number of jaw tags returned by anglers from rainbow trout released at the Indian Trail boat ramp on May 5, 1970. Tag returns broken down by month for 1970 and for the entire years of 1971 and 1972. Data from Hill (1973).

	Holter Reservoir	Missouri River
May	11	5
June	20	49
July	14	98
August	9	30
September	30	11
October	24	11
November	20	7
December	12	2
Total	140	213
Tag Returns 1971	94	51
Tag Returns 1972	14	6
TOTAL TAG RETURNS	248	270

In another test reported by Hill (1973), 195,000 six-inch rainbow trout were stocked in Holter Reservoir on July 14, 1970; 47,000 of the fish were adipose-fin clipped. During 1971, 556 of the clipped fish were handled in creel surveys conducted on Holter Reservoir and the Missouri River. Of the clipped fish, 48% were caught in the reservoir and 52% were caught in the river between the dam and the Wolf Creek Bridge (Table 15). Only four of the clipped fish (less than 1% of the total) were caught in lower portions of the river. As reported above for the experiment with the jaw-tagged fish, most of the adipose-fin clipped fish showed up in the river creel in July. Again, this may have been partly due to the high fishing pressure during that month. Nonetheless, the temporal pattern of clipped fish in the creel bears a striking resemblance to the discharge pattern for the same time period (Figure 12), and suggests a causal relationship. There was high discharge (and spill) during much of May, followed by a cessation of all spilling and a big drop in total discharge during much of June, followed by a resurgence of flows to above 15,000 cfs during July. The number of adipose-fin clipped fish observed in the river creel surveys showed a similar drop from 45 in May to 27 in June and back up to 169 in July.

The 1986 Canyon Ferry tailrace creel survey showed that the number of fish flushed from the reservoir decreased as the fall progressed. When the creel survey was broken into two-week intervals, nine hatchery fish from Canyon Ferry were caught during the first interval from September 20-October 3, more than during any subsequent interval (Table 16). The percent of total juvenile fish that were of Canyon Ferry origin during this first interval was 56.2%. In subsequent intervals, percent of Canyon Ferry fish was 66.7%, 33.3%, 50.0% and finally 0% by the time of the last interval (November 15-28). Consistent with this trend were catch numbers from tailrace electrofishing conducted during the summer and fall. The percent of juveniles that were Canyon Ferry fish declined from 31.8% (Arlees and DeSmets combined) on August 5/6 to 25.8% on September 22 and to 11.1% on October 27 (Table 17). Both the creel survey and electrofishing showed a drop in numbers during a time when flows were generally increasing. Specific flow conditions that existed during this time were: 1) spillways were not used during the fall; 2) turbine discharge dropped slowly from about 5,000 cfs in July to less than 4,000 cfs October and then back over 5,000 cfs by the end of November; 3) the river gates were used for only 6 days in August (releasing between 100 and 700 cfs); and 4) the Helena Valley turbine released between 200 and 400 cfs in August, and decreased to 40 cfs on its last day of operation on October 1st (Figure 13). Changes in Canyon Ferry water-surface elevations were small as well: pool elevation dropped slowly from full pool on June 30 to eight feet down on August 31 and back up to five feet down on November 30. One possible explanation for the drop in percent of hatchery fish in the tailrace through the fall is that the fish in the forebay were moving to shallower water in October and November, and away from the depth of the penstock intakes. As mentioned previously, fish will occupy depths to at least 70 feet in September, while in October and November the maximum depths for most fish are 50 feet and 15 feet, respectively.

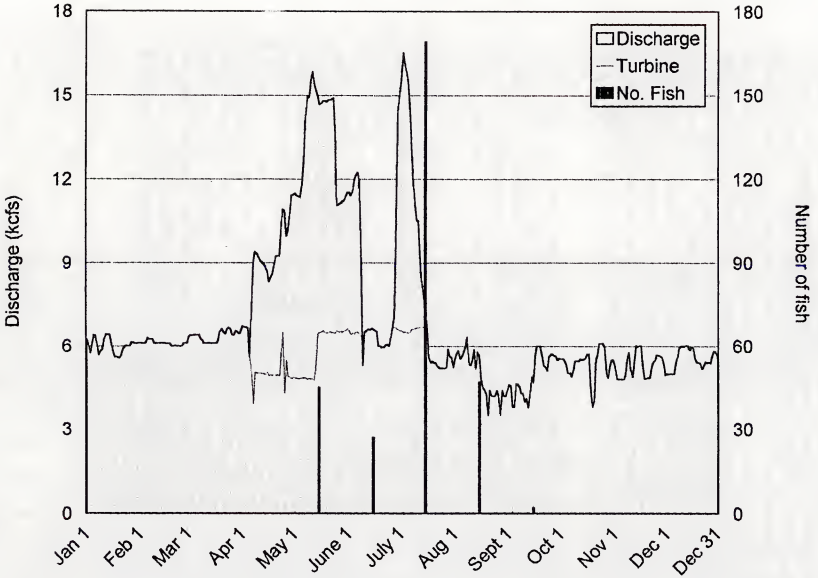


Figure 12. Plot of discharge from Holter Dam during 1971. All water above the dotted line was spilled; everything below the line went through the turbines. Vertical bars indicate monthly totals of the number of adipose-clipped fish in the tailrace creel.

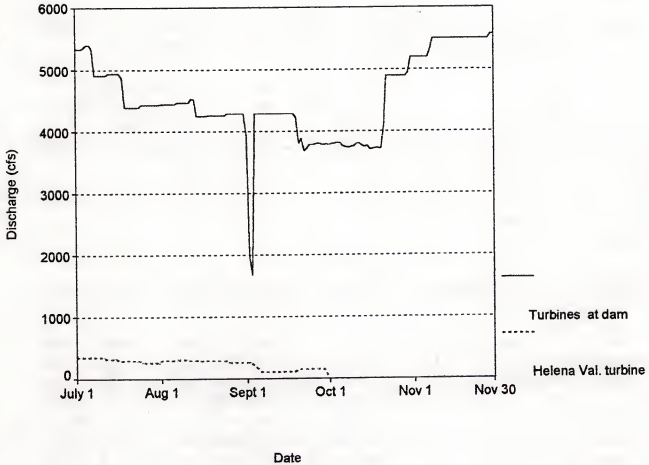


Figure 13. Discharge from Canyon Ferry Dam turbines and Helena Valley turbines, July - December, 1986.

Table 15. Adipose-fin clipped trout observed in the creel during the summer of 1971. Fish had been stocked in the reservoir on July 14, 1970. Data from Hill (1973).

	Holter Reservoir	Missouri River Dam to Wolf Creek Bridge	Missouri River 1 Mile Below Dam to Cascade
May	18	45	0
June	88	27	1
July	114	169	1
August	29	47	2
September	13	2	0
TOTAL	**262**	**290**	**4**

In the 1987 Missouri River creel survey, 52% of the rainbow trout that were creeled between the dam and Wolf Creek Bridge were fish that had been stocked in Holter Reservoir in 1986 (Table 7). April, May and June were the only three months where the sample size was greater than ten fish. During these months, the percent of creeled rainbow trout that were spray-marked rose from 25% to 38% to 70%. The drop in the number caught in July and August (to zero) is probably a reflection of the relatively few number of days that creel was conducted. Without adequate numbers for July and August, it is not appropriate to conclude that June is the peak month. Nonetheless, the increase in the percent of hatchery fish from April to June does not coincide with any period of increasing discharge from the dam, and in fact the flows in June were lower than in April and the first part of May, and only slightly higher than the last half of May (Figure 14). Vertical fish distribution may provide an explanation for this. At Holter, most hatchery fish occupy water shallower than the penstock intakes in May (Figure 4), and so may be less prone to entrainment than in June when they are moving to deeper water.

As part of the 1993 Missouri River creel survey, fish were inspected for spray marks from May through September. Based on these inspections, the number of Holter fish in the creel rose from a low of three in May (9.4% of total creeled rainbows) to a high of 48 in July (50.5% of total) and then dropped slightly to 31 in September (41.9% of total)(Table 8). In order to compare these numbers to short-term changes in dam discharge, we calculated 10-day running averages of the percent of Holter fish in the creel. The hatchery fish stocked in 1993 started to show up in the creel in late September; these fish were excluded from the comparison so as to not inflate the percent hatchery values in September relative to the prior months. This comparison shows that the percent of Holter hatchery fish did not rise until spill began in June (Figure 15). The increase in number of fish in June and eventual drop in August seems to lag behind the spike in discharge by several weeks, suggesting that the quantity of water discharged is affecting flushing rates, but that the effect is slow to express

Table 16. Results of 1986 Canyon Ferry tailrace creel showing the number, percent and origin of rainbow trout inspected in the creel. Canyon Ferry fish are either DeSmet or Arlee strain planted in 1986; Hauser fish were Arlee strain fish planted in 1986.

Time Period	Number of Adults	Number of Juveniles: No Mark	Adipose Clip (Hauser)	Spray-mark (Canyon Ferry)	Total
9/20-10/3	12	1	6	9	16
	% of juveniles: 6.2%	37.5%	56.2%		
10/4-10/17	12	0	2	4	6
	% of juveniles: 0.0%	33.3%	66.7%		
10/18-10/31	31	0	4	2	6
	% of juveniles: 0.0%	66.7%	33.3%		
11/1-11/14	29	0	3	3	6
	% of juveniles: 0.0%	50.0%	50.0%		
11/15-11/28	24	0	4	0	4
	% of juveniles: 0.0%	100.0%	0.0%		

Table 17. Results from Canyon Ferry tailrace electrofishing in fall 1986, showing the number, percent and origin of captured rainbow trout.

Time Period	Number of Adults	Number of Juveniles: No Mark	Adipose Clip (Hauser)	Spray-mark/Canyon Ferry (Arlee)	(DeSmet)	Total
August 5,6	10	20	55	28	7	110
	% of juveniles:	18.2%	50.0%	25.5%	6.3%	
September 22	9	19	27	14	2	62
	% of juveniles:	30.6%	43.5%	22.6%	3.2%	
October 27	13	31	25	5	2	63
	% of juveniles:	49.2%	39.7%	7.9%	3.2%	

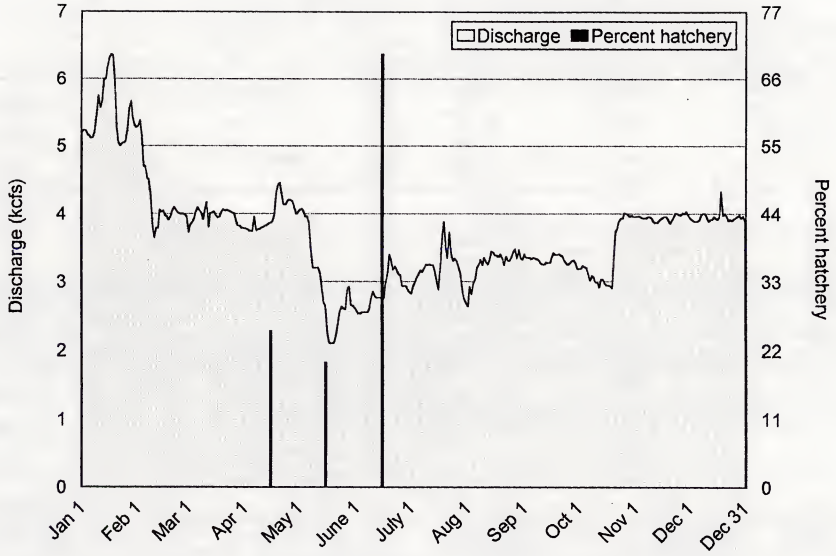


Figure 14. Plot of discharge from Holter Dam during 1987. All water was discharged through the turbines. Vertical bars indicate monthly totals of the percent of rainbow trout handled in the Missouri River creel that were hatchery fish from Holter Reservoir.

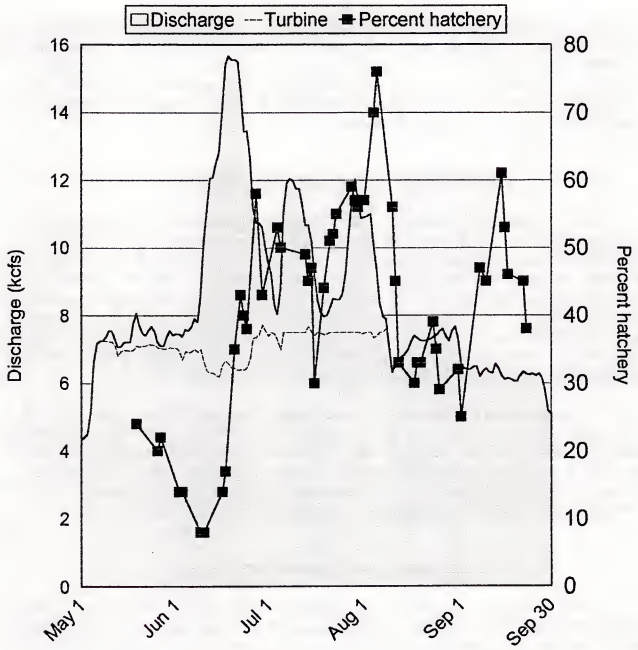


Figure 15. Plot of discharge from Holter Dam during 1993. All water above the dotted line was spilled; everything below the line went through the turbines. Solid line is a 10-day running average of the percent of rainbow trout in the tailrace creel that were hatchery fish. Markers represent midpoint of 10-day intervals.

itself in the creel. However, there was no increase in discharge in September that explains the pulse of fish in that month. Rather, discharge slowly decreased through the month and there was no spill. Regardless of an explanation for the pulse in September, the high percent of hatchery fish in that month might be expected because the fish are still in deeper water and prone to entrainment. This is in contrast to the low percent of hatchery fish flushed during May, during a period that fish are residing at depths shallower than the penstocks.

Contribution to Downstream Reservoir Fisheries

The contribution of flushed fish to the rainbow trout populations and angler harvest in downstream reservoirs was determined from gill net catches and creel surveys for the years 1986-1995. The annual contribution of Canyon Ferry rainbows to the Hauser Reservoir rainbow population was estimated to average 9.3% in spring horizontal gill nets, 5.3 % in fall horizontal gill nets, 5.1% in vertical gill nets, and 2.1% in the reservoir creel (Table 18). These percentages were strongly influenced by the high rates from 1993 to 1995. The annual contribution of flushed rainbows to Holter Reservoir was considerably less than for Hauser. Hatchery fish from Canyon Ferry and Hauser made up only 2.0% of all rainbows in spring gill net catches on Holter, 0.4% in fall gill nets, and 0.2% in both vertical gill nets and the reservoir creel (Table 19).

The actual number of flushed fish that were harvested by anglers on Hauser and Holter was estimated by using creel survey statistics developed for the reservoirs (rainbow catch rates and average trip length) and angler pressure estimates. For the two most recent pressure estimates (1993 and 1995), the harvest of Canyon Ferry hatchery rainbows in Hauser during the summer (May-September) was estimated to be 147 and 1,512, respectively. On Holter, harvest estimates of Canyon Ferry and Hauser rainbows during the summer were 82 for 1993 and 62 for 1995.

Contribution to the Missouri River Fishery

In the years 1971, 1987 and 1993, the Missouri River creel surveys showed that the vast majority of hatchery rainbows flushed from Holter Reservoir were caught in the 2.5-mile section of the river between the dam and Wolf Creek bridge. In 1971, only 4 of 294 hatchery rainbow trout were caught downstream of the Wolf Creek bridge; all the rest were caught between the dam and bridge. In 1987, the creel survey extended from the dam downstream to Ulm (58.2 miles below the dam). However, all 43 marked hatchery rainbow trout observed during the creel survey were caught in the first 0.5 miles below the dam. The 1993 creel covered the same stretch of river between the dam and Ulm, and 128 of 130 hatchery fish were caught between the dam and Wolf Creek bridge. Of these fish, 50% were caught in the first 0.1 miles below the dam and the remainder were in the first 1.4 miles below the dam. Of the 2 hatchery rainbows caught downstream of the Wolf Creek bridge, one was caught between Wolf Creek bridge and Craig, and the other between Dearborn Inn and Mountain Palace Fishing Access site (Table 8). These two fish represented only 1.2% of the 171 rainbow trout creeled downstream of Wolf Creek bridge. This low percentage suggests that few

Table 18. Relative contribution of rainbow trout flushed from Canyon Ferry Reservoir to rainbow trout gill net catches and angler harvest in HauserReservoir, 1986-1995.

Year	Hatchery Rainbows from Canyon Ferry as a Percent of Total Rainbow Catch Horizontal Gill Nets (spring)	Horizontal Gill Nets (fall)	Vertical Gill Nets	Reservoir Creel Survey (Summer and following winter)
1986	0.0	2.2	2.3	2.9
1987	0.0	2.4	0.0	0.3
1988	0.0	1.1	0.0	0.2
1989	0.0	2.4	0.0	0.1
1990	0.0	0.0	0.0	0.5
1991	4.8	5.1	0.0	0.3
1992	0.0	0.0	0.0	0.2
1993	4.8	19.4	11.1	0.9
1994	27.8	8.1	20.0	1.5
1995	55.9	12.2	17.6	13.8
Mean	**9.3**	**5.3**	**5.1**	**2.1**

Table 19. Relative contribution of rainbow trout flushed from Canyon Ferry and Hauser reservoirs to rainbow trout gill net catches and angler harvest in Holter Reservoir, 1986-1995.

Year	Hatchery Rainbows from Canyon Ferry and Hauser reservoirs as a Percent of Total Rainbow Catch			
	Horizontal Gill Nets (spring)	Horizontal Gill Nets (fall)	Vertical Gill Nets	Reservoir Creel Survey (Summer and following winter)
1986	9.8	0.8	1.7	0.4
1987	10.0	0.6	0.0	0.1
1988	0.0	0.0	0.0	0.1
1989	0.0	2.9	0.0	0.1
1990	0.0	0.0	0.0	0.1
1991	0.0	0.6	0.0	0.1
1992	0.0	0.0	0.0	0.0
1993	0.0	0.0	0.0	0.3
1994	0.0	0.0	0.0	0.6
1995	0.0	0.0	0.7	0.4
Mean	**2.0**	**0.4**	**0.2**	**0.2**

hatchery fish reside in this portion of the river. Electrofishing surveys in the Craig Section (Wolf Creek Bridge to Craig Bridge) support this conclusion. Only 4 of 367 rainbow trout (1.1% of total) electrofished in this area on October 25, 1993 were hatchery fish from Holter reservoir (file data).

Electrofishing surveys in the Holter Section of the river in 1986, 1987 and 1993 also support the trends indicated by the creel surveys. In all three years, the percent of rainbow trout that were of hatchery origin decreased from Reach A (dam to MPC Campground--0.5 miles) to Reach C (1.5 to 2.5 miles below the dam--ending at the Wolf Creek bridge). The percentage drop was highest in 1987, dropping 11-fold from 6.6% hatchery in Reach A to 0.6% in Reach C (Table 20). The drop was more moderate in the other years, dropping from 36.8% to 4.3% in 1986 and 39.7% to 8.3% in 1993.

Because so many hatchery fish are flushed into the Holter Section of the river, it raises the possibility that they may be having an impact on the wild trout populations due to competition for food and/or space. This competition seems most likely for wild fish of a similar size to the age 0+ Arlees. At this time, the only measure we have that indicates the potential for competition is the percentage of trout in the river that are of hatchery origin. In the higher flow years of 1986 and 1993, age 0+ Arlee fish composed 47.8% and 32.1%, respectively, of all rainbow trout of a similar size in the 2.5-mile reach below the dam. In the low flow year of 1987, Arlees represented only 9.0% of fish of a similar size. Hatchery fish make up a much smaller percentage when compared to the total trout population. In the same 2.5-mile reach of river, Arlee hatchery fish represented 1,711/7,210 or 23.7% of the total rainbow trout population in 1986, and 1,280/9,448 or 13.5% of the total in 1993.

Changes in the locations of fish stocking.

Certain aspects of fish stocking practices have changed on the three reservoirs between 1986-1995. How these changes may have affected flushing rates is a very difficult question to answer, given the large number of variables. We will not attempt to provide an answer here, but will simply mention some of the prominent changes that have occurred. One change that has occurred on all reservoirs is that of tempering the water in hatchery trucks. Prior to 1995, it was a universal practice to temper the water of hatchery trucks with lake water prior to releasing fish. This practice was stopped in 1995 as a result of concern for contamination of hatchery equipment by Myxobolis (whirling disease).

On Canyon Ferry Reservoir, the Big Springs hatchery has been responsible for about 45% of the number of fish stocked during the 1986-1995 period. The remaining 55% have come from the Bluewater, Giant Springs and Creston hatcheries. At least 13 locations have been used over the years for stocking, ranging from Kim's Marina at the north end to the Missouri River at the south end near the Fish, Wildlife and Parks offices. Most of the plants have been made from shore, but a number of plants were made by boat in the 1980s.

Table 20. Catch of hatchery and wild rainbow trout during Missouri River electrofishing surveys in the Holter Section, 1986, 1987 and 1993. Reach A: dam to MPC campground; Reach B: campground to bottom of island on east bank/Lahti's shed; Reach C: bottom of island/Lahti's shed to Wolf Creek bridge. "Hatchery" totals include only those fish that had been stocked in the same year as the electrofishing survey.

	Reach A		Reach B		Reach C	
	Hatchery	Wild	Hatchery	Wild	Hatchery	Wild
			1986			
Marked fish	95	149	44	132	13	295
Captured fish	115	211	47	286	14	313
Recaptured fish	10	12	2	24	3	45
R/C	8.7%	5.7%	4.3%	8.4%	21.4%	14.4%
% hatchery (of all fish)	36.8%		17.9%		4.3%	
			1987			
Marked fish	11	184	4	198	3	240
Captured fish	13	152	3	171	0	249
Recaptured fish	2	10	0	12	0	27
R/C	15.4%	6.6%	0.0%	7.0%	0.0%	10.8%
% hatchery (of all fish)	6.6%		1.9%		0.6%	
			1993			
Marked fish	33	51	44	316	26	329
Captured fish	24	37	69	430	30	348
Recaptured fish	0	6	4	20	4	44
R/C	0.0%	16.2%	5.8%	4.7%	13.3%	12.6%
% hatchery (of all fish)	39.7%		14.0%		8.3%	

On Hauser Reservoir, only four locations have ever been used: Lakeside Marina, Riverside, York Bridge and the Causeway. All fish have come from the Giant Springs hatchery, except in 1988, when the fish came from Big Springs hatchery.

Plants in Holter Lake have changed somewhat over the years. From 1986 to 1988, all fish were planted at either Log Gulch or Indian Trail boat ramps. Between 1989 and 1994, the approximate distribution of plants was 50% at Log Gulch, 25% at the Gates of the Mountains and 25% at the BLM ramp near the dam. In 1995, plants were made only at the Gates (28%) and Log Gulch(72%). All fish stocked into Holter during this period have come from the Big Springs hatchery.

ANALYSIS OF FISH-FLUSHING HYPOTHESIS

The analysis of the retention of hatchery fish in Hauser and Holter reservoirs (see Tables 11, 12 and 13) provided indirect evidence that our hypothesis was correct in predicting that flushing rates would be related to quantity of discharge and spill. Retention (based on horizontal gillnet catches) in the reservoirs was negatively correlated with quantity of turbine discharge and spill, and partial correlations suggested that turbines and spillways both contribute to flushing. These relationships were strongest for Hauser Reservoir, where the strength of the correlations was due primarily to the high net catches in the dry year of 1988 and low net catches in the wet years of 1993 and 1995.

There were several occasions where we could confidently attribute fish flushing to operation of the spillways. This was clearly inferred in the years 1970, 1971 and 1993 below Holter Dam, where returns to the creel of hatchery fish increased shortly after spilling began, and then subsequently dropped off after spilling ceased (Figures 11, 12 and 15).

There were also numerous situations where spilling did not occur, and we knew that all flushed fish had come through the turbines or river gates (in the case of Canyon Ferry Dam). At Holter Dam in 1986, 1987 and 1988, there was no spilling between the time of stocking and tailrace electrofishing in the fall, yet 47.8%, 9.0% and 6.8%, respectively, of the rainbow trout captured during electrofishing activities were age 0+ Arlees from Holter Reservoir. Moreover, all of the 1,711 Arlees estimated to be in the Holter tailrace in October 1986 must have come through the turbines that year. At Canyon Ferry Dam, no spill occurred in 1986, 1987, 1988 and 1989 between the time of stocking and tailrace electrofishing in the fall. However, the Canyon Ferry hatchery rainbows made up 22.6%, 2.5%, 0.6%, and 22.9%, respectively, of all rainbows captured during tailrace electrofishing in each of the four years.

We were unable to verify the assumption that it is necessary for fish to be at the depth of the penstock intakes in order to be entrained. Such an assumption implies that fish must be moving laterally to enter the penstocks, rather than getting sucked in quickly from a much different depth. To confirm this would require simultaneous measurements of fish densities at different depths in the forebay as well as in the tailrace during times when only the turbines were running (no spill). We

only have circumstantial evidence, but it suggests that the fish may not have to be at exactly the depth of the penstocks in order to be entrained. This evidence comes from the Canyon Ferry tailrace electrofishing surveys in the fall of 1986 and 1987. Rainbow trout are assumed to not inhabit water deeper than 70 feet, based on the vertical gill net catches. The top of the penstocks are at the 70-ft depth level only when the reservoir is 14 feet below full pool. When tailrace electrofishing surveys were conducted in 1986 and 1987, 22.6% and 2.5% of the captured fish were from Canyon Ferry, even though the top of the penstocks were at depths of 76-84 feet in 1986 and 72-74 feet in 1987. Even more, 29.4% of the rainbows captured in 1986 during the first electrofishing survey on August 5/6 were from Canyon Ferry, even though the top of the penstocks had been at 81-84 feet since the start of July. Either hatchery rainbows are residing at depths as great as 80 feet, or else they are being sucked into the penstocks quickly from shallower water. In either case, it is clear that trout are susceptible to entrainment at practically any pool elevation during the months of July through September.

There is other evidence to show that fish are entrained when they are at or near the depth of the penstocks. This comes from three creel surveys--the 1986 Canyon Ferry tailrace creel and the 1987 and 1993 Holter tailrace creels. In all three surveys, there was no obvious relationship between changes in the percent of hatchery fish and quantity of discharge during periods when there was turbine discharge only (no spill). However, several observations suggest the appearance of hatchery rainbows in tailwaters was related to the juxtaposition of trout at the depth of the penstocks in the upstream reservoir. In the 1986 Canyon Ferry tailrace creel, the drop in percent of Canyon Ferry rainbows in October and November was consistent with the movement of reservoir hatchery fish into shallower water at that time of year and away from penstock intakes. The increase in percent of hatchery fish in angler creels below Holter Dam from May to June 1987 was consistent with the fish moving to deeper water during this time and to the depth of the penstocks in Holter Reservoir. The much lower percent of hatchery rainbows in angler creels below Holter Dam in May as compared to September 1993 was consistent with the reservoir fish residing at depths shallower than the penstocks in May and at or deeper than penstock depth in September. These interpretations should be viewed with caution because creel survey data are very indirect indicators of flushing; it is not possible to know exactly when an angler-caught fish came through the turbines.

QUANTIFICATION OF FISH FLUSHING

None of the work reported here allows us to quantify the actual number of fish flushed through any of the dams. Hill (1973) estimated that about half of the stocked rainbows are flushed out of Holter Reservoir each year during the time of spilling. He based this on the voluntary return of jaw-tagged fish which were planted in Holter Reservoir in 1970 (see Table 14). Between the time of stocking and the end of 1972, 270 jaw-tagged fish were returned from the river (52% of the total), while 240 were returned from the reservoir (48% of the total). The assumption that the percent of tag returns coming from the river represents the percent of fish that had flushed into the river is probably inappropriate. To use a percentage in this way, the following conditions would have to be similar for both the reservoir and river: 1) trout population levels (both wild and hatchery); 2) angler pressure; and 3) catch rates for rainbow trout. Catch rates were similar for both river and reservoir,

but there was no data to suggest similarity for the first two conditions. In fact, it seems most likely that the trout population and angler pressure on the reservoir were higher than in the river. Given these uncertainties, we cannot use the numbers to make an estimate of the percent of fish flushed through the dam.

The only occasion where even a rough estimate of total flushing losses can be calculated is the flushing of Holter Reservoir fish in 1993. During that year, the population estimate of 7-13 inch Arlees from Holter in the 2.5-mile section of the Missouri immediately below the dam was 1,280 fish during November (Table 5). That same year, an estimated 1,658 hatchery fish were harvested by anglers in the same section of river in the months preceding the population estimate (Table 21). The combined total is 2,938 fish, slightly less than 1% of the number stocked into Holter Reservoir each year. Certainly many more fish than this were actually flushed through the dam. Some were likely killed during passage through or over the dam, others probably drifted downstream out of the section or were victims of natural mortality and predation prior to the population estimate in November.

RECOMMENDATIONS

In his report, Hill (1973) recommended that fish be stocked after high water so as to minimize the flushing losses. Results from our analysis suggest that this is still good advice. We have presented strong circumstantial evidence supporting Hill's conclusion that flushing losses can be substantial during spill events. However, we have also shown that entrainment losses through the turbines can be high, e.g. the large number of hatchery fish found in the Holter tailwaters in 1986. We also suspect that turbine entrainment will be a greater problem at Hauser and Holter dams than at Canyon Ferry, due to the much greater portion of the year that fish are at the depth of the penstock intakes at those two dams. Admittedly, we have little data to support this, and even if it was a well established fact, it leaves us with few options. The only time of year that we could avoid spill and also stock fish when they are unlikely to reside at the depth of the penstocks is in late fall--October or November. Stocking fish at these times may impractical from several standpoints--fish of the desired size may not be available from the hatchery system, and overwinter survival of fish stocked this late in the fall is generally regarded as poor.

We have also shown that retention of hatchery fish is correlated with quantity of turbine discharge and spill. Potentially, this information could be used to help allocate trout each spring when accurate water supply forecasts become available. Surplus fish from the hatchery system could be stocked into these reservoirs during dry years, or in particularly wet years, some of the fish destined for these reservoirs could be stocked elsewhere.

Table 21. Pressure and harvest estimates for hatchery and wild rainbow trout in the Holter Section of the Missouri River, 1993. Holter Section extends from Holter Dam down to the Wolf Creek Bridge.

Month	Pressure estimate (angler hours)	Catch rate (no./hr)	(a) % Total rainbow harvest est.	(b) of creeled fish that were hatchery fish from Holter Res.	Total hatchery fish harvest (a x b)
May	2405	0.19	349	9.4	33
June	3474	0.29	594	27.0	160
July	6246	0.27	1,1795	0.5	595
August	4324	0.44	1,3934	2.4	590
September	3082	0.52	668	41.9	280
TOTAL	**19,531**		**4,183**		**1,658**

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